

Date July 21, 1986

NASA CR-179505
Vol II



National Aeronautics and
Space Administration

(NASA-CR-179505-Vol-1-2) DETERMINATION OF THE
RELATIVE RESISTANCE TO IGNITION OF SELECTED
TURBOPUMP MATERIALS IN HIGH-PRESSURE,
HIGH-TEMPERATURE, OXYGEN ENVIRONMENTS,
VOLUME 2 Interim Report (NASA) 226 p

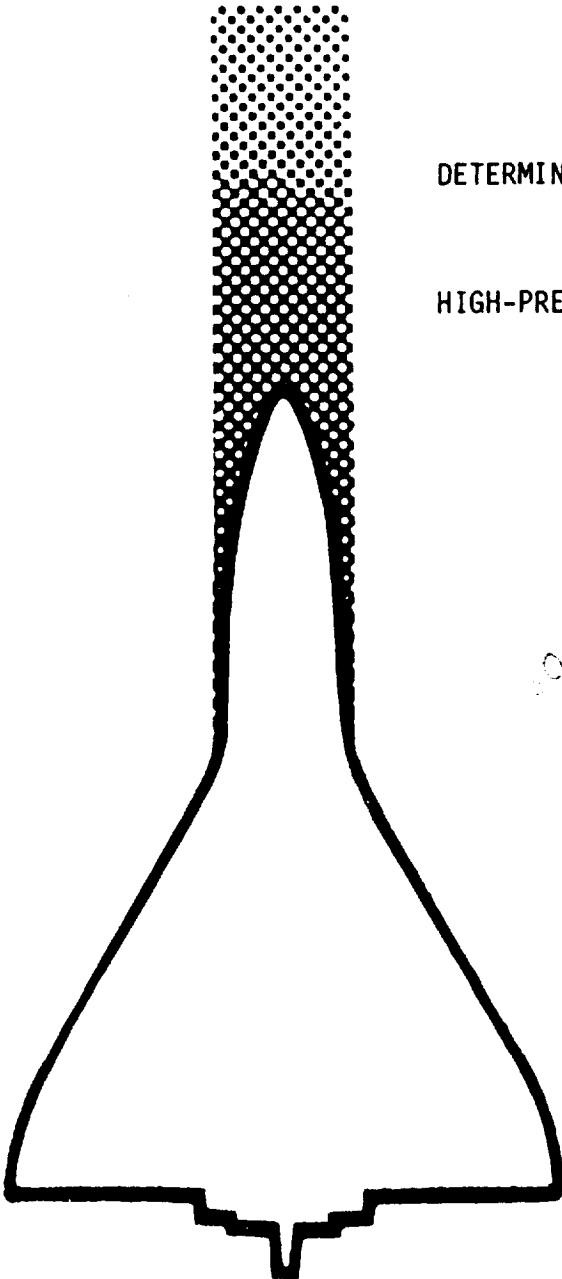
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TEST REPORT

VOLUME II

DETERMINATION OF THE RELATIVE RESISTANCE TO IGNITION
OF SELECTED TURBOPUMP MATERIALS IN
HIGH-PRESSURE, HIGH-TEMPERATURE, OXYGEN ENVIRONMENTS



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White Sands Test Facility
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Las Cruces, New Mexico 88004
AC 505 524-5011

TEST REPORT
DETERMINATION OF THE RELATIVE RESISTANCE TO IGNITION
OF SELECTED TURBOPUMP MATERIALS IN
HIGH-PRESSURE, HIGH-TEMPERATURE, OXYGEN ENVIRONMENTS

VOLUME II

Issued By
National Aeronautics and Space Administration
Johnson Space Center
White Sands Test Facility
Laboratories Test Office

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ABSTRACT

Advances in the design of the liquid oxygen, liquid hydrogen engines for the Space Transportation System call for the use of warm, high-pressure oxygen as the driving gas in the liquid oxygen turbopump. The NASA Lewis Research Center requested the NASA White Sands Test Facility (WSTF) to design a test program to determine the relative resistance to ignition of nine selected turbopump materials: Hastelloy X, Inconel 600, Invar 36, Monel K-500, Monel 400, nickel 200, silicon carbide, stainless steel 316, and zirconium copper. The materials were subjected to particle impact and to frictional heating in high-pressure oxygen.

In the particle impact tests, nickel 200, Monel 400, and silicon carbide were the most resistant to ignition; Monel K-500 and zirconium copper were slightly less resistant to ignition; and Hastelloy X, Invar 36, and stainless steel 316 were the least resistant to ignition. Inconel 600 was not tested.

In frictional heating tests of pairs of like materials, the ranking was generally upheld, with the materials ranked in order of decreasing resistance to ignition as follows: nickel 200, Inconel 600, Monel 400, Monel K-500, Hastelloy X, Invar 36, and stainless steel 316. Pairs of silicon carbide and zirconium copper failed mechanically at modest contact pressures and did not ignite.

In tests where pairs of different materials were rubbed together, the material rated less resistant to ignition in previous tests appeared to control the resistance to ignition of the pair.

Tests designed to determine the effects of oxygen pressure on the results of frictional heating appeared to indicate that the greater heat rates per unit area required to ignite metals at high pressures resulted from increased convective heat losses from the test samples.

PREFACE

This interim report addresses the test series that resulted from three test plans written at the NASA White Sands Test Facility in response to a request from the NASA Lewis Research Center to determine the relative compatibility of selected turbopump materials in gaseous oxygen. The first test plan, Determination of the Ignition Sensitivity of Selected Turbopump Metals in High Pressure, High Temperature, Oxygen Environments (TP-WSTF-324), proposed tests in which eight materials were impacted with particles in hot, high-pressure oxygen and nine materials were heated frictionally in high-pressure oxygen. The second test plan, TP-WSTF-324 ADDI, proposed tests in which pairs of different materials were rubbed together in high-pressure oxygen to induce frictional heating. The third test plan, Evaluation of Pressure Effects in the WSTF Friction Rubbing Test System (TP-WSTF-356), proposed tests to determine the effects of the test gas pressure on the results of frictional heating tests. Testing proposed in the first and third test plans has been completed, and six of the eight tests proposed in the second test plan have been completed.

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Table C-1. Particle Impact Tests on Hastelloy X Configured as Impact Plates

Test Number	Inlet Gas Temperature (°F)	Inlet Gas Pressure (psig)	Results
129.01	762	4525	Sample Partially Burned
130.01	815	4511	Sample Partially Burned
132.01	779	4477	No Burning
133.01	751	4588	No Burning
134.01	758	4553	No Burning
135.01	748	4574	No Burning
136.01	794	4553	Sample Partially Burned
138.01	781	4523	No Burning
139.01	778	4539	Sample Partially Burned
140.01	759	4504	No Burning
156.01	795	4518	Slight Evidence of Burning
158.01	754	4532	No Burning
159.01	764	4539	No Burning
160.01	743	4525	No Burning
161.01	759	4490	Sample Partially Burned
162.01	701	4539	No Burning
163.01	730	4581	No Burning
164.01	738	4532	Sample Partially Burned
167.01	705	4650	No Burning

Table C-2. Particle Impact Tests on Invar 36 Configured as Impact Plates

Test Number	Inlet Gas Temperature (°F)	Inlet Gas Pressure (psig)	Results
69.01	710	4500	No Burning
70.01	726	4511	Sample Completely Burned
71.01	799	4477	Sample Completely Burned
72.01	699	4400	No Burning
73.01	714	4504	No Burning
74.01	722	4497	Sample Completely Burned
75.01	687	4539	No Burning
76.01	693	4490	No Burning
77.01	684	4497	No Burning
78.01	726	4518	Sample Completely Burned
168.01	730	4560	Sample Completely Burned
169.01	681	4504	Sample Completely Burned

Table C-3. Particle Impact Tests on Monel K-500 Configured as Impact Plates

Test Number	Inlet Gas Temperature (°F)	Inlet Gas Pressure (psig)	Results
102.01	753	4525	No Burning
103.01	775	4539	No Burning
104.01	782	4532	No Burning
105.01	782	4490	No Burning
106.01	777	4601	No Burning
107.01	822	4567	Slight Evidence of Burning
108.01	825	4456	No Burning
124.01	779	4511	No Burning
125.01	796	4453	No Burning
126.01	769	4608	No Burning

Table C-4. Particle Impact Tests on Monel 400 Configured as Impact Plates

Test Number	Inlet Gas Temperature (°F)	Inlet Gas Pressure (psig)	Results
93.01	718	4483	No Burning
94.01	772	4518	No Burning
95.01	714	4483	No Burning
96.01	774	4477	No Burning
97.01	794	4497	No Burning
98.01	736	4483	No Burning
99.01	725	4393	No Burning
100.01	786	4372	No Burning
127.01	775	4532	No Burning
128.01	767	4546	No Burning

Table C-5. Particle Impact Tests on Nickel 200 Configured as Impact Plates

Test Number	Inlet Gas Temperature (°F)	Inlet Gas Pressure (psig)	Results
15.01	522	4546	No Burning
15.02	629	4594	No Burning ^a
15.03	677	4747	No Burning ^a
15.04	706	4553	No Burning ^a
15.05	655	4581	No Burning ^a
15.06	700	4511	No Burning ^a
15.07	720	4629	No Burning ^a
15.08	714	4567	No Burning ^a
15.09	708	4567	Slight Evidence of Burning ^a
15.10	700	4594	No Burning ^a
110.01	789	4560	No Burning
111.01	816	4574	No Burning
112.01	814	4560	No Burning
113.01	821	4532	No Burning
114.01	794	4407	No Burning

a: Test done using same impact plate that was used in previous test.

Table C-6. Particle Impact Tests on Silicon Carbide Configured as Impact Plates

Test Number	Inlet Gas Temperature (°F)	Inlet Gas Pressure (psig)	Results
148.01	818	4581	No Burning ^a
149.01	604	4560	No Burning ^a
150.01	787	4553	No Burning
152.01	773	4553	No Burning
153.01	792	4525	No Burning ^a
154.01	762	4643	No Burning ^a
155.01	780	4525	No Burning

a: Impact plate shattered on impact.

Table C-7. Particle Impact Tests on Stainless Steel 316 Configured as Impact Plates

Test Number	Inlet Gas Temperature (°F)	Inlet Gas Pressure (psig)	Results
43.01	631	4553	Sample Completely Burned
47.01	469	4574	Sample Completely Burned
49.01	441	4504	No Burning
50.01	443	4483	Sample Completely Burned
53.01	480	4449	Sample Completely Burned
54.01	476	4581	No Burning
55.01	435	4456	No Burning
58.01	498	4560	No Burning
62.01	606	4574	No Burning
63.01	617	4525	Sample Partially Burned
64.01	592	4546	No Burning
65.01	644	4407	No Burning
66.01	631	4483	Sample Completely Burned
67.01	623	4574	No Burning
141.01	560	4490	No Burning
142.01	518	4532	No Burning
143.01	478	4483	No Burning
144.01	467	4511	No Burning
172.01	495	4532	Sample Partially Burned
173.01	454	4574	Sample Partially Burned
174.01	439	4483	No Burning
175.01	459	4581	Sample Completely Burned
176.01	425	4497	No Burning

a: Impact plate shattered on impact.

Table C-7. Particle Impact Tests on Stainless Steel 316 Configured as Impact Plates (Continued)

Test Number	Inlet Gas Temperature (°F)	Inlet Gas Pressure (psig)	Results
177.01	421	4532	No Burning
178.01	436	4643	No Burning
179.01	423	4629	Sample Partially Burned
180.01	403	4490	No Burning
181.01	401	4483	Sample Partially Burned
182.01	392	4477	No Burning
183.01	385	4525	No Burning

Table C-8. Particle Impact Tests on Zirconium Copper Configured as Impact Plates

Test Number	Inlet Gas Temperature (°F)	Inlet Gas Pressure (psig)	Results
80.01	696	4608	No Burning
81.01	788	4379	No Burning
82.01	728	4477	Slight Evidence of Burning
83.01	756	4449	Slight Evidence of Burning
84.01	755	4615	No Burning
117.01	726	4546	No Burning
118.01	781	4546	No Burning
119.01	789	4560	No Burning
120.01	773	4497	No Burning
121.01	758	4463	No Burning

Table C-10. Particle Impact Tests on Stainless Steel 316 Configured as
Rupture Disks 0.38 mm (0.015 in) Thick

Test Number	Inlet Gas Temperature (°F)	Inlet Gas Pressure (psig)	Results
25.02	274	4497	No Rupture, No Burning
26.01	294	4511	No Rupture, No Burning
27.01	367	4460	Rupture, No Burning
28.01	468	4463	Rupture, No Burning ^a
29.01	438	4574	Rupture, No Burning

a: Disk ruptured prior to injection of particles.

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APPENDIX D

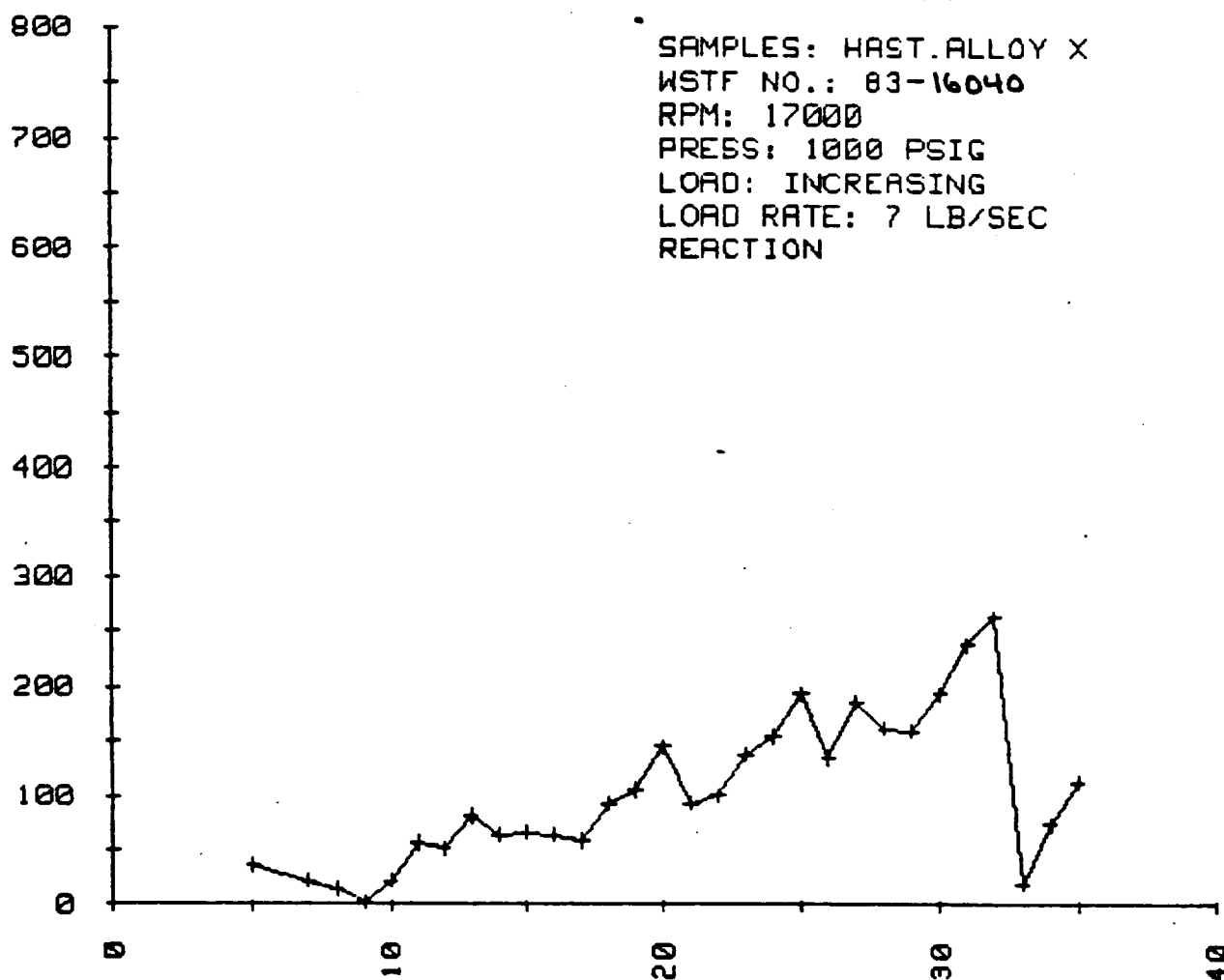
Data From Frictional Heating
Tests on Like Materials

TEST NUMBER	TEST MATERIAL	PAGE
151	Hastelloy X	D-1
152		D-9
153		D-17
194	Inconel 600	D-25
195		D-32
196		D-39
149	Invar 36	D-46
150		D-54
154		D-62
179	Monel K-500	D-70
180		D-78
181		D-86
162	Monel 400	D-94a
163		D-95
164		D-109
142	Nickel 200	D-116
144		D-124
161		D-132
177	Silicon Carbide	D-139
178		D-147
140		D-155
141	Stainless Steel 316	D-163
143		D-171
146		D-170
147	Zirconium Copper	D-187
148		D-195

FRT #151 TEST #2 6/17/83

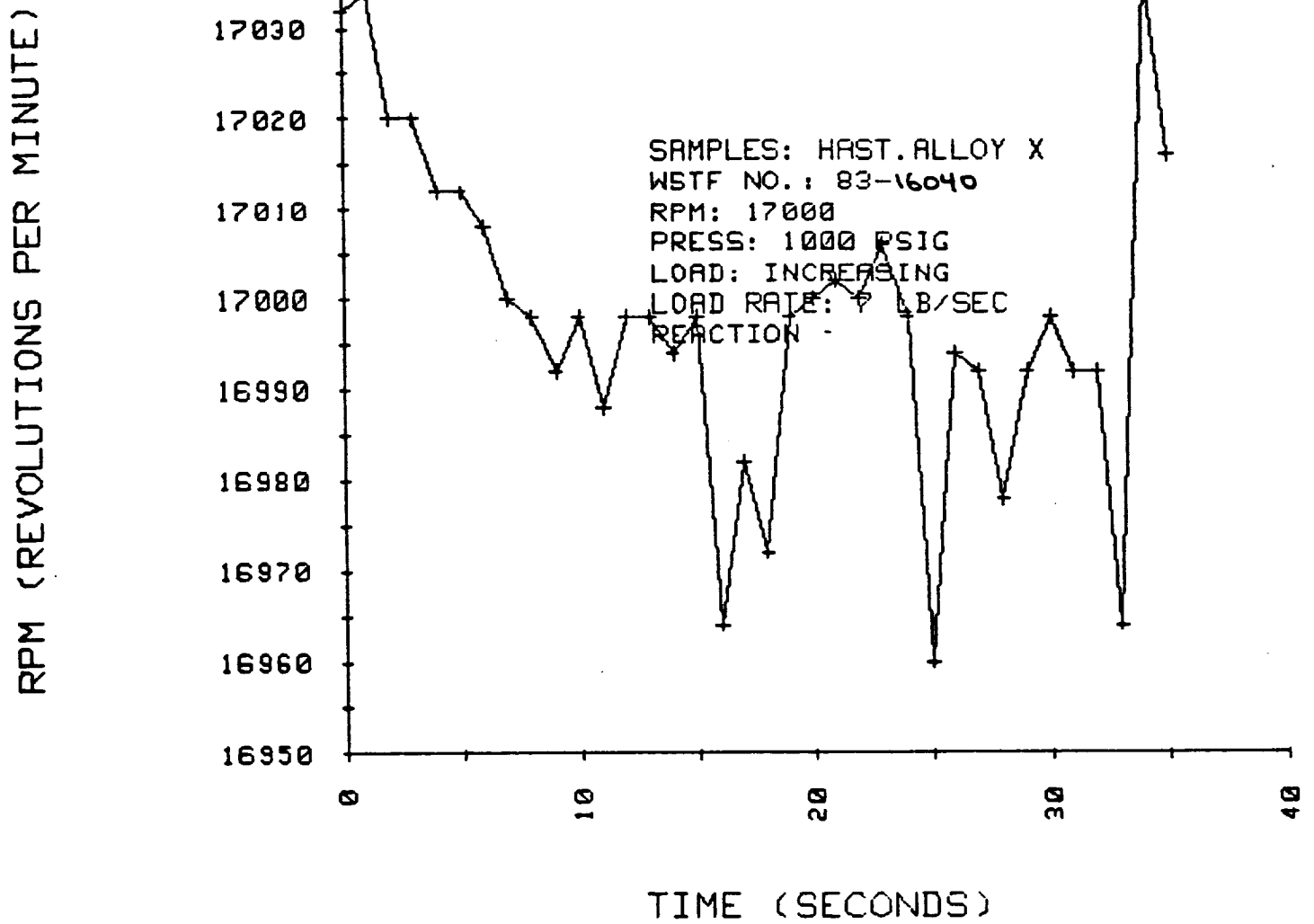
SAMPLES: HAST.ALLOY X
WSTF NO.: 83-16040
RPM: 17000
PRESS: 1000 PSIG
LOAD: INCREASING
LOAD RATE: 7 LB/SEC
REACTION

SAMPLE LOAD (POUNDS)



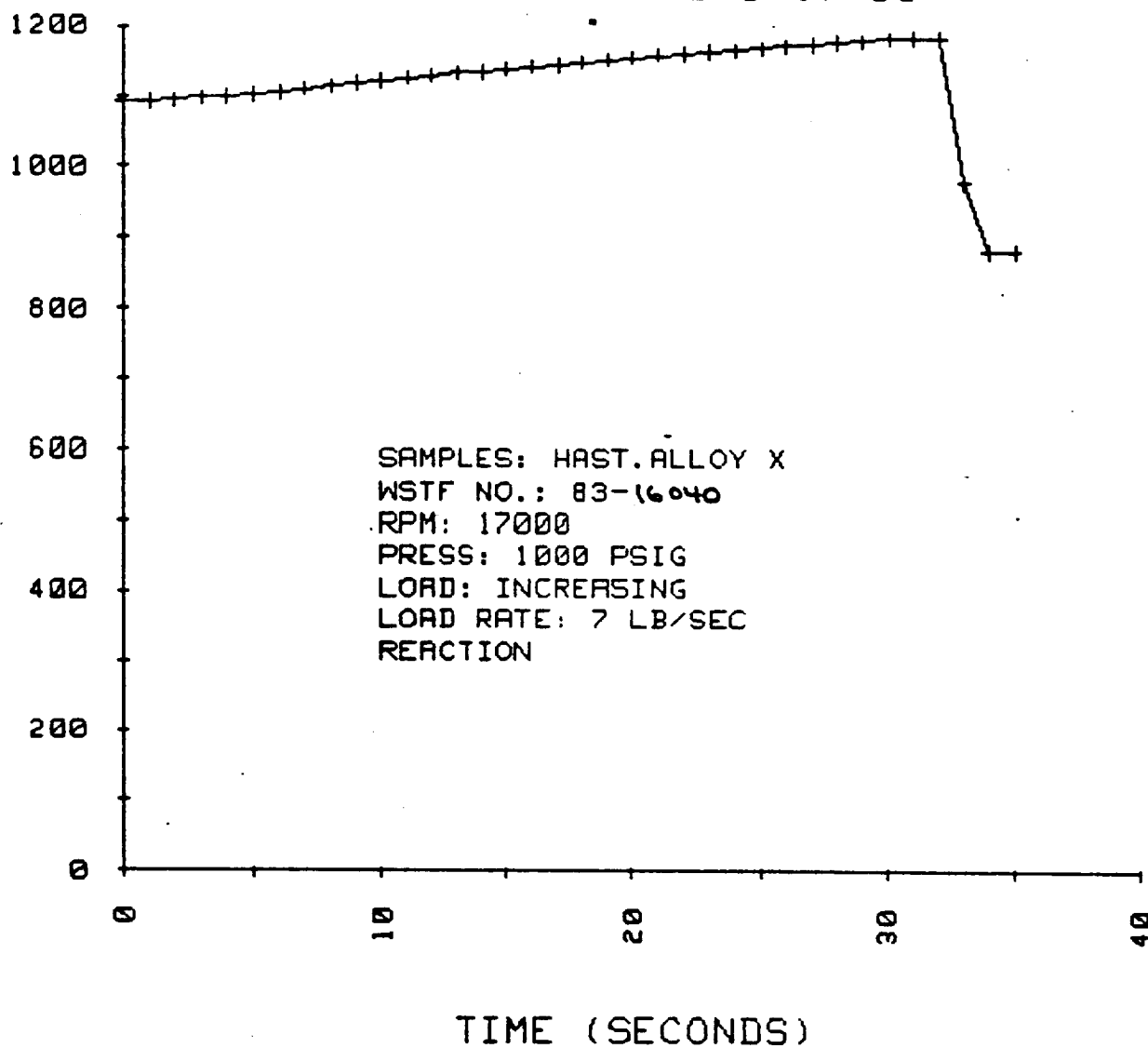
TIME (SECONDS)

FRT #151 TEST #2 6/17/83



CHAMBER PRESSURE (PSIG)

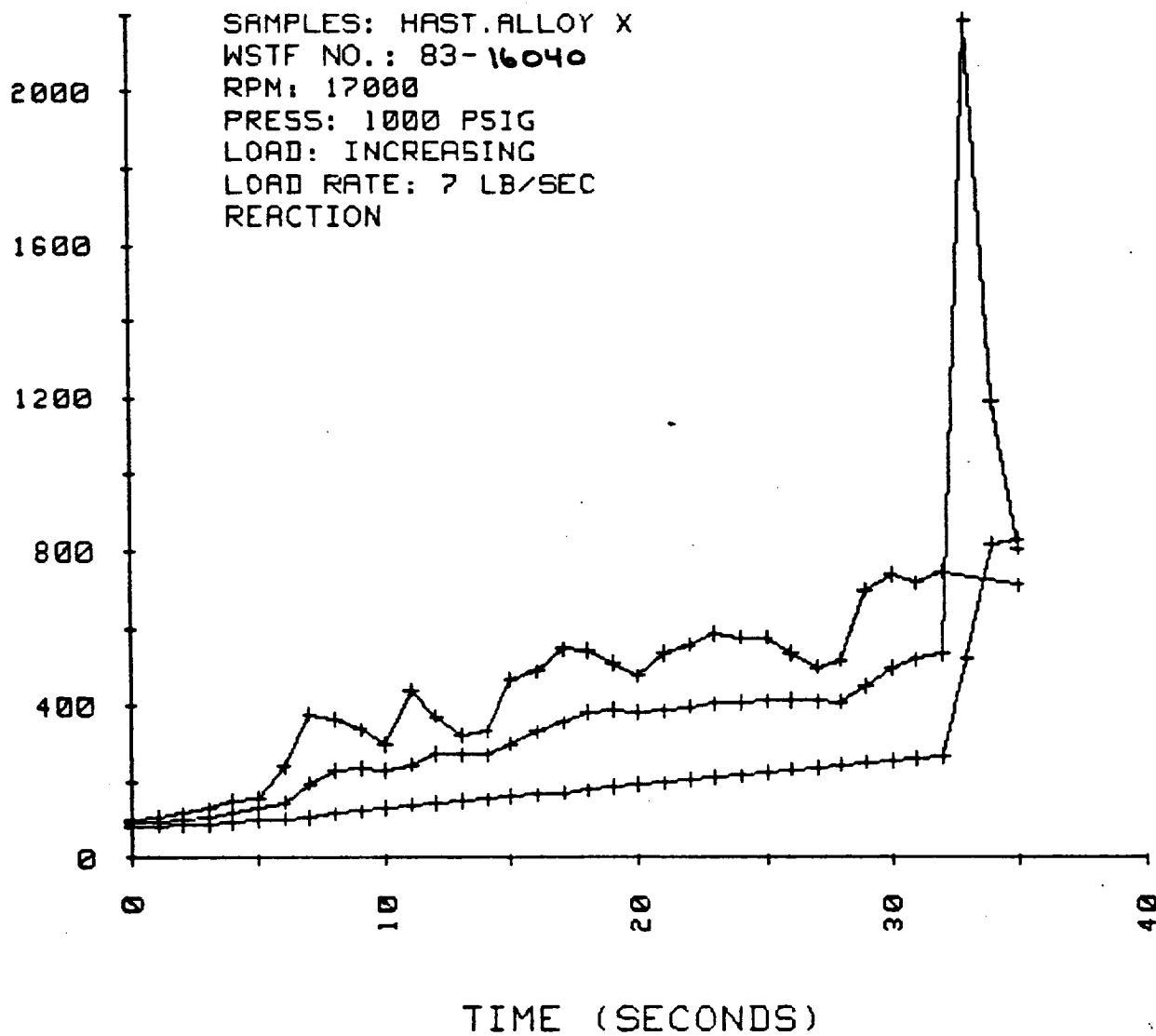
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FRT #151 TEST #2 6/17/83

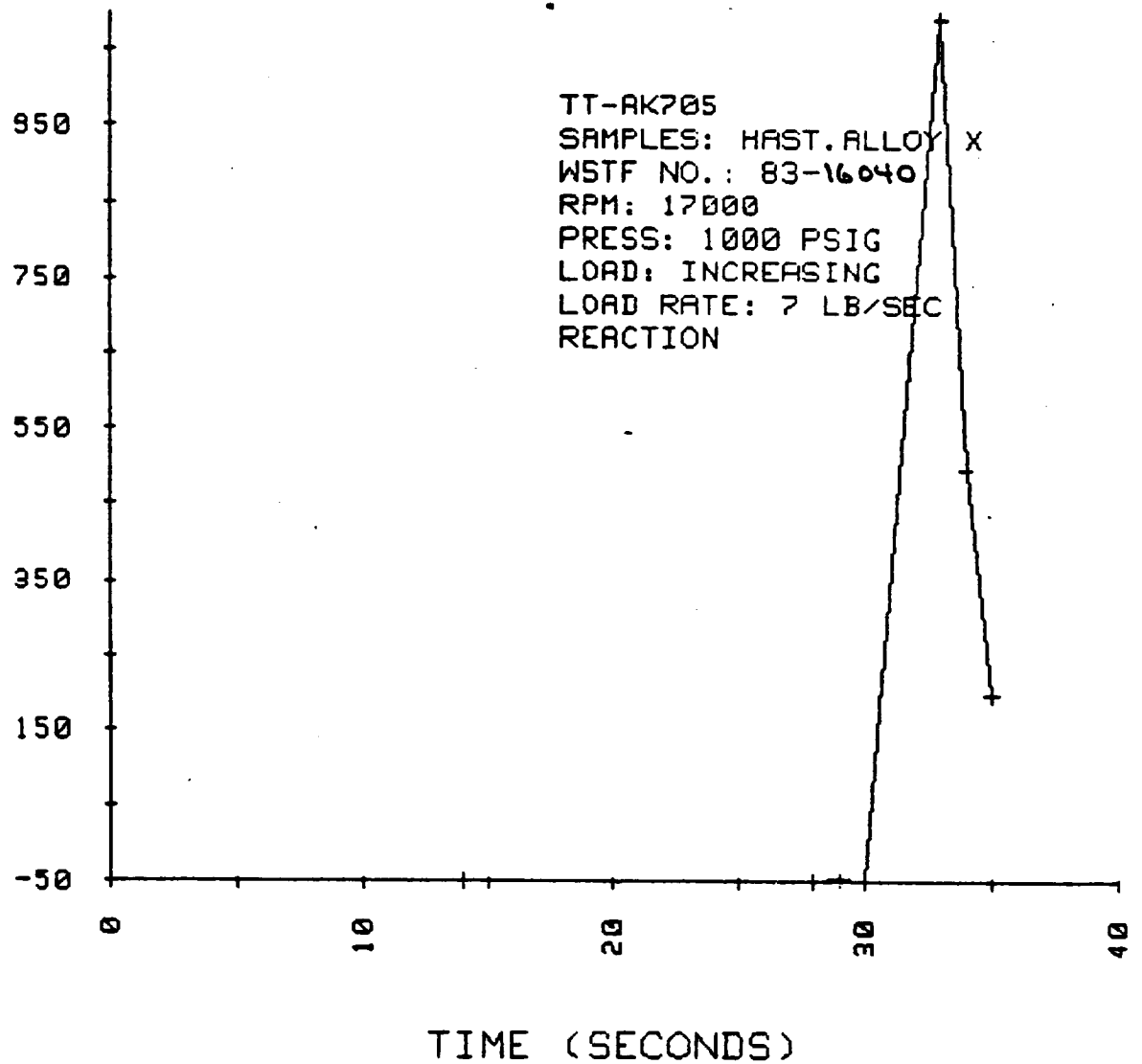
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WSTF NO.: 83-16040
RPM: 17000
PRESS: 1000 PSIG
LOAD: INCREASING
LOAD RATE: 7 LB/SEC
REACTION

TEMPERATURE (DEG F)



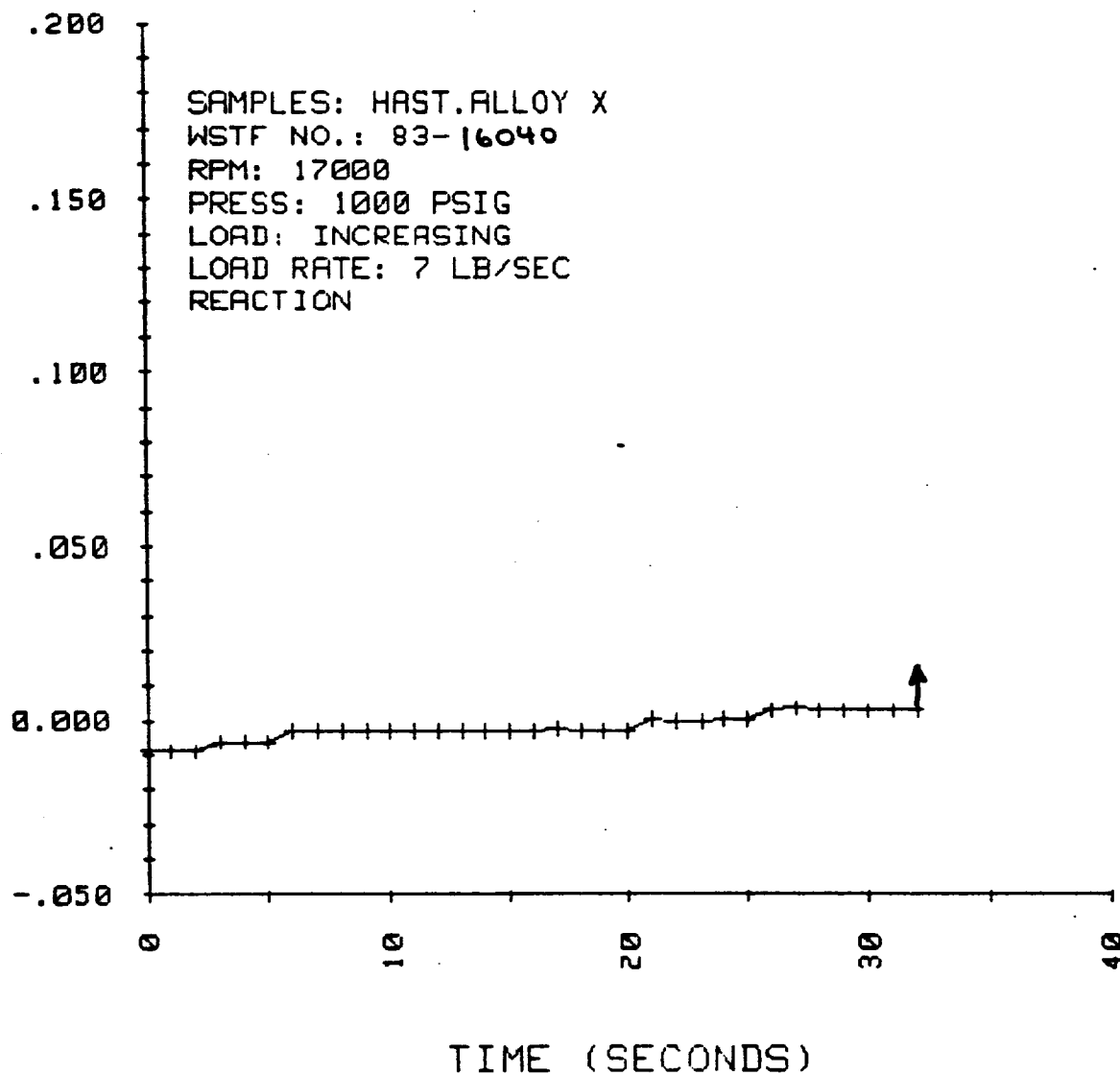
FRT #151 TEST #2 6/17/83

THERMOPILE OUTPUT (1/100MV)



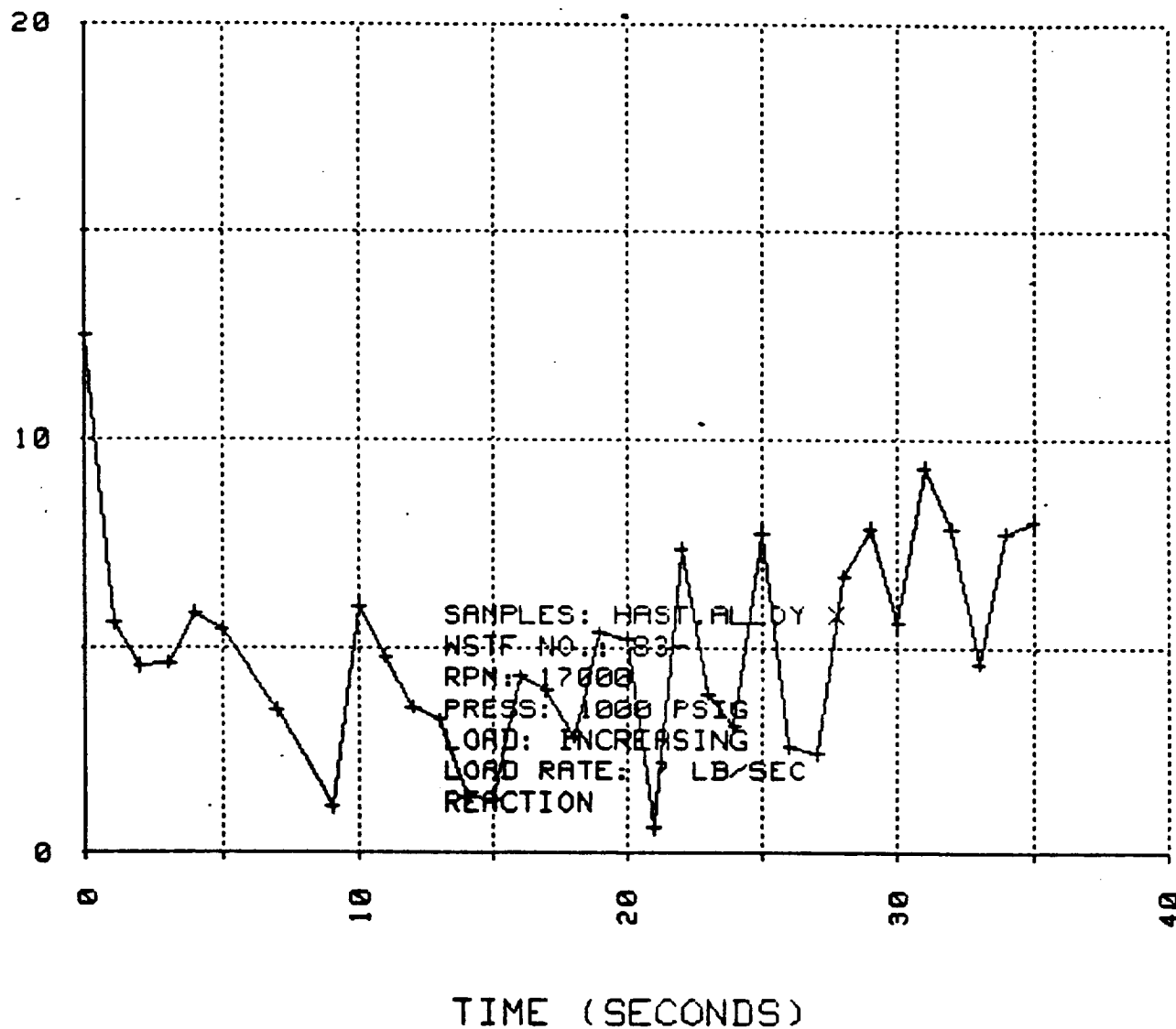
SAMPLE DISPLACEMENT (INCHES)

FRT #151 TEST #2 6/17/83



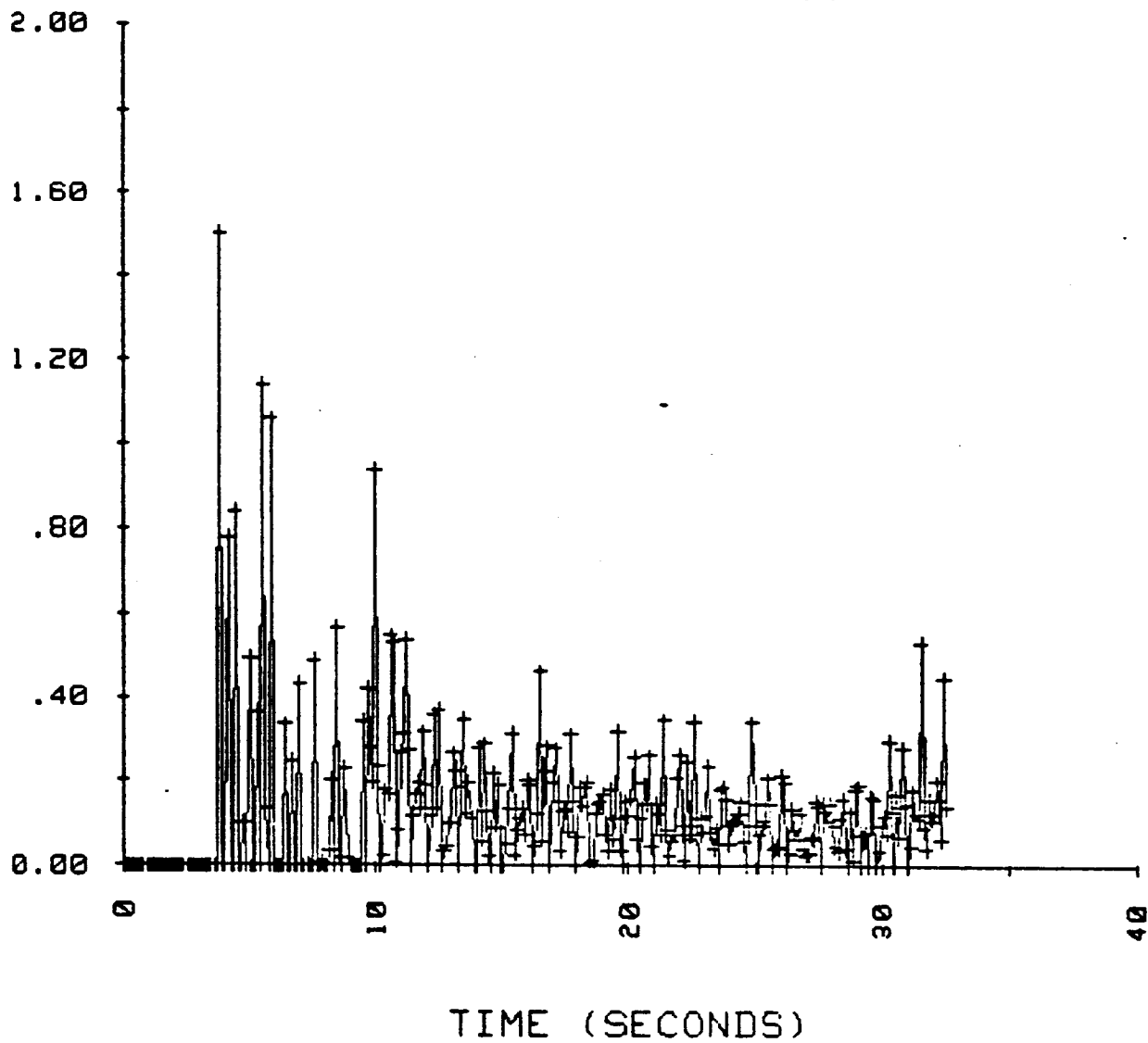
CHAMBER TORQUE LOAD (POUNDS)

FRT #151 TEST #2 6/17/83



COEFFICIENT OF FRICTION

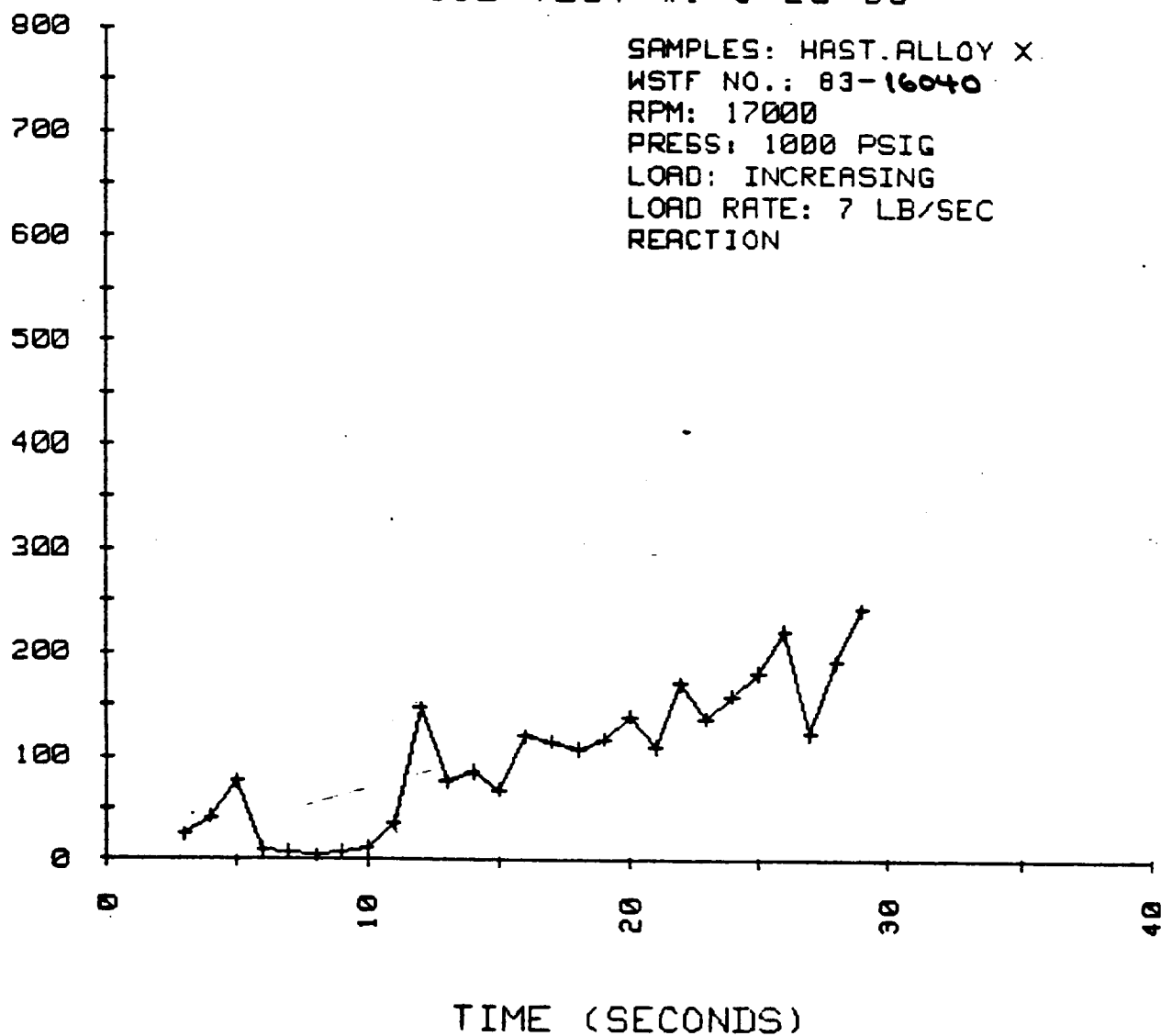
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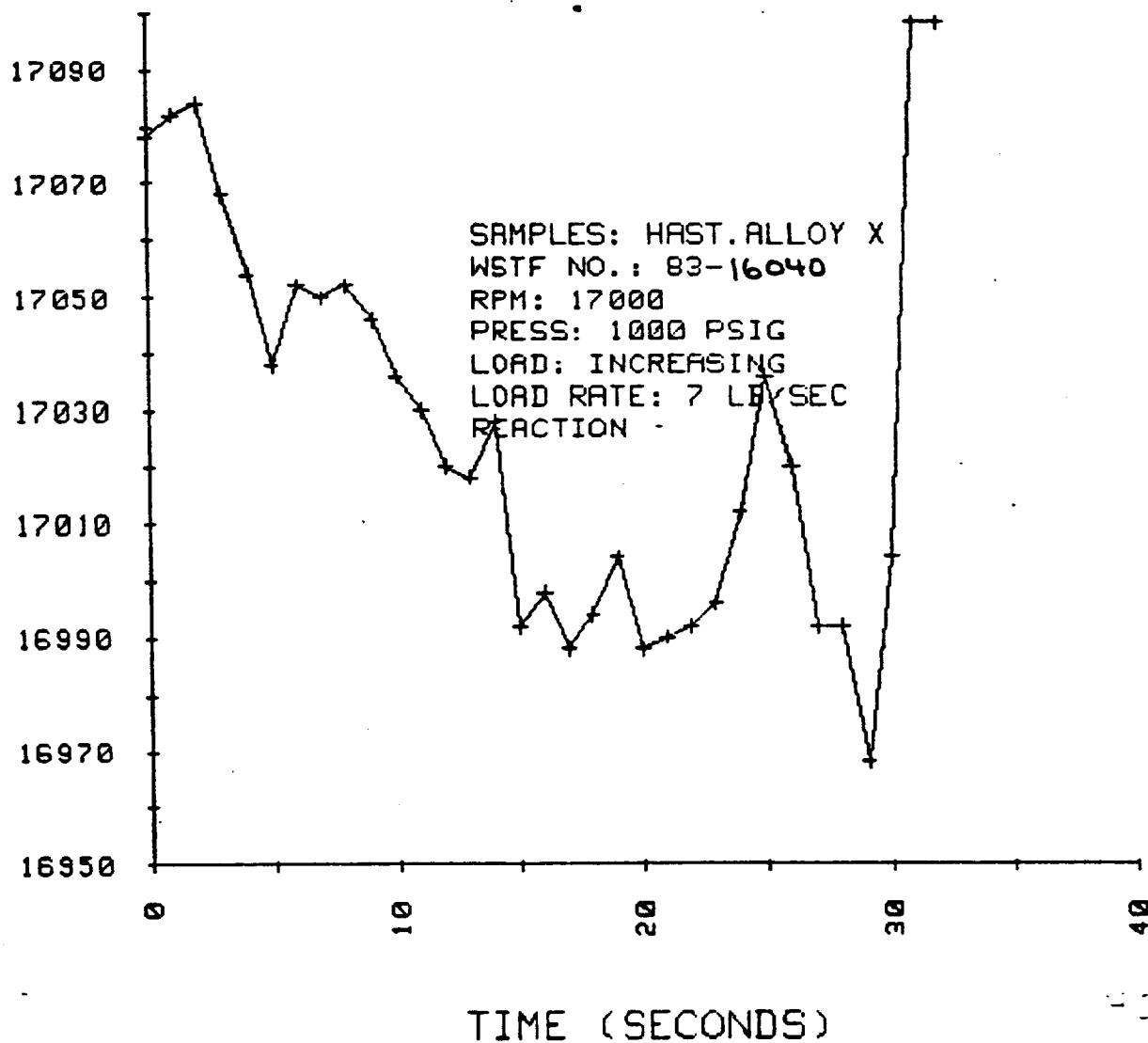
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WSTF NO.: 83-16040
RPM: 17000
PRESS: 1000 PSIG
LOAD: INCREASING
LOAD RATE: 7 LB/SEC
REACTION

SAMPLE LOAD (POUNDS)



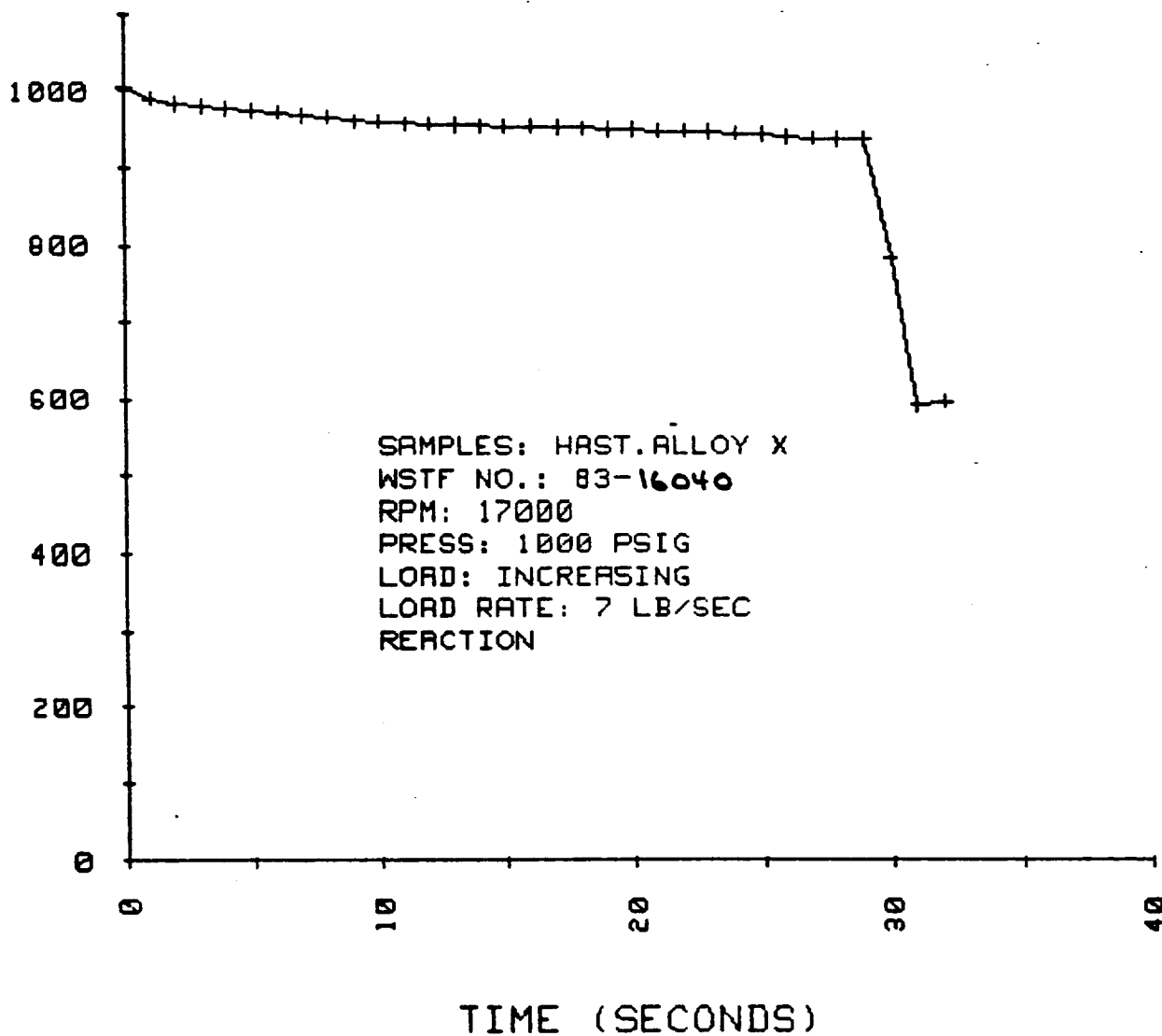
FRT #152 TEST #1 6/20/83

RPM (REVOLUTIONS PER MINUTE)



FRT #152 TEST #1 6/20/83

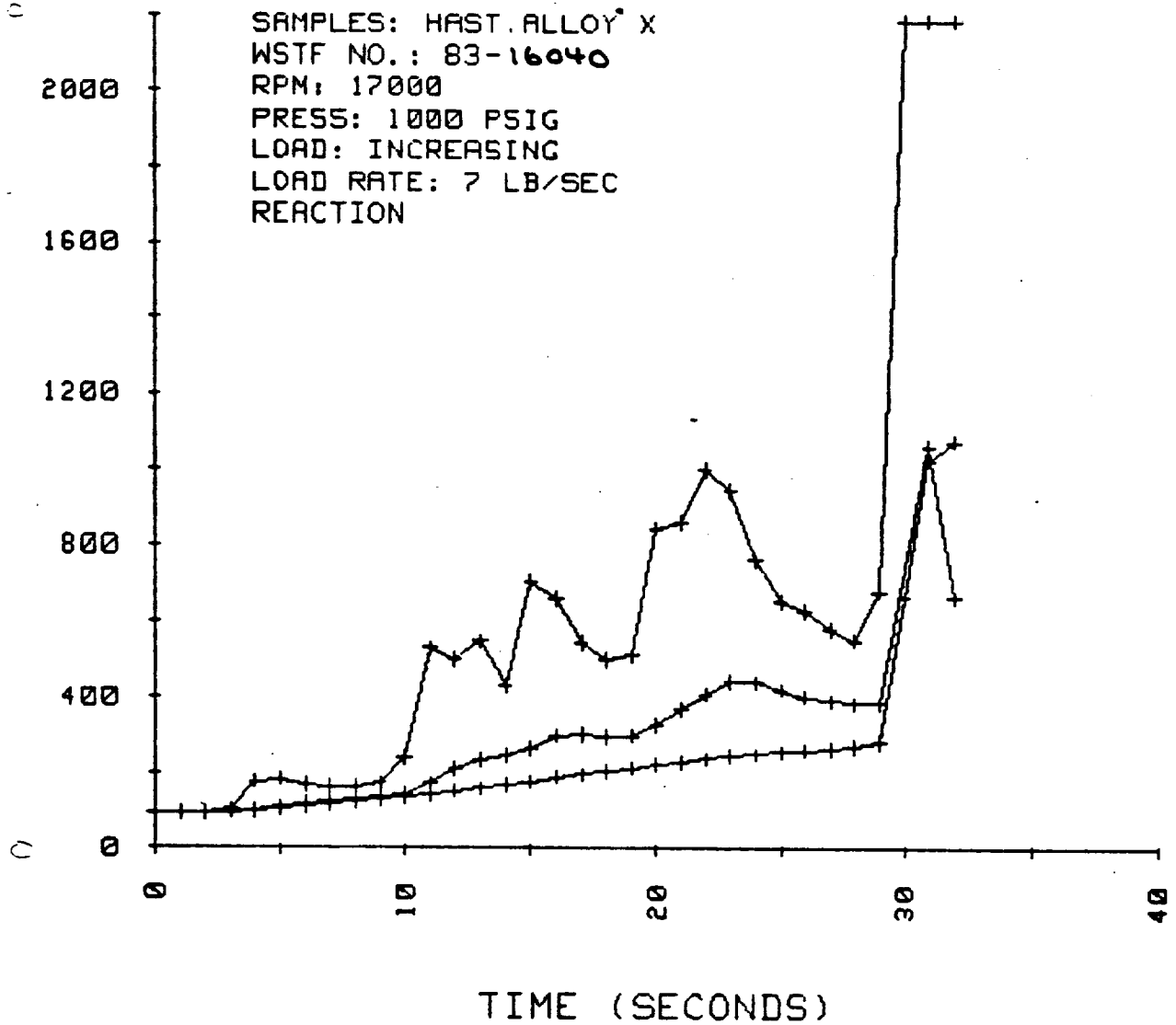
CHAMBER PRESSURE (PSIG)



FRT #152 TEST #1 6/20/83

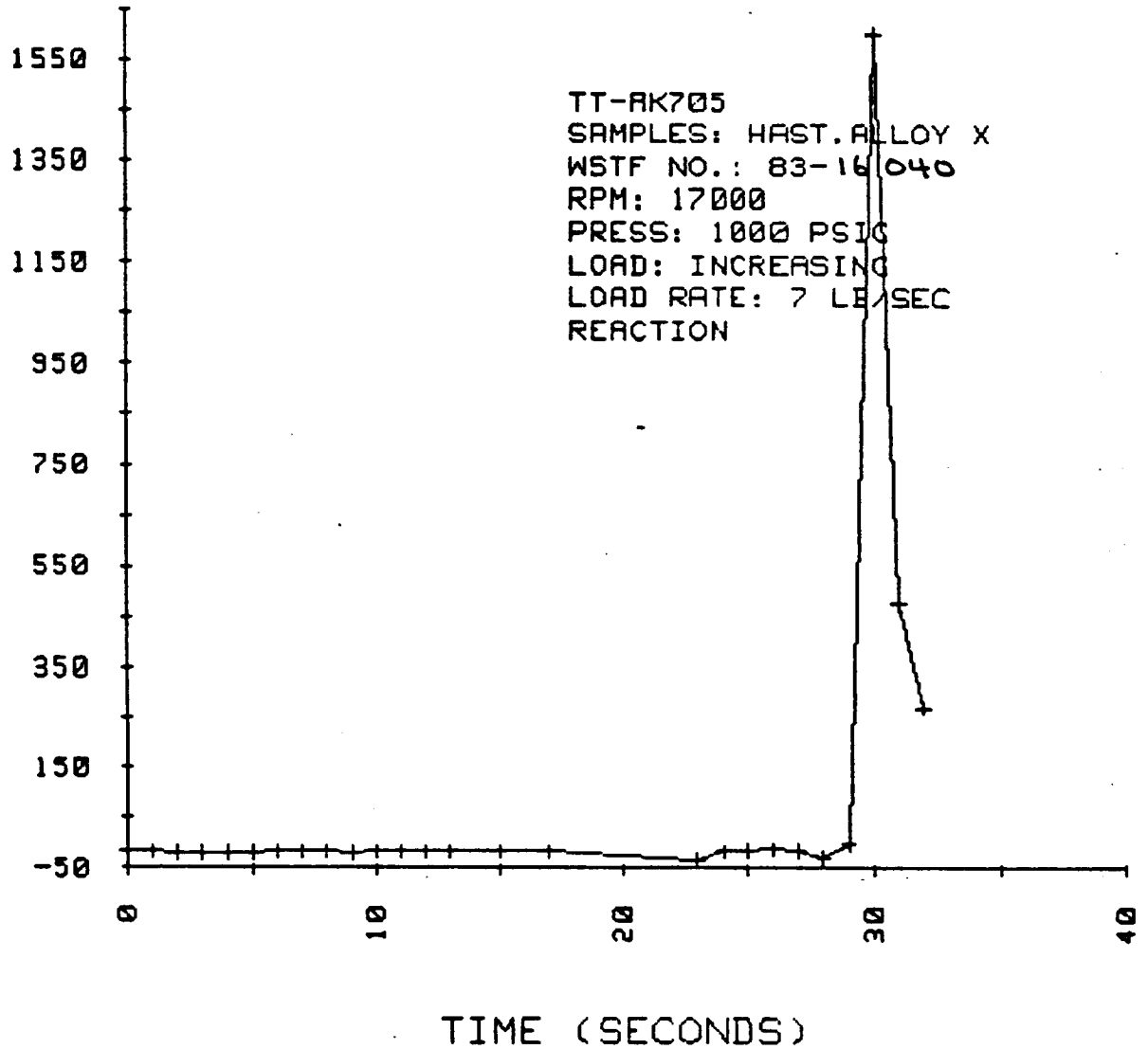
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 WSTF NO.: 83-16040
 RPM: 17000
 PRESS: 1000 PSIG
 LOAD: INCREASING
 LOAD RATE: 7 LB/SEC
 REACTION

TEMPERATURE (DEG F)



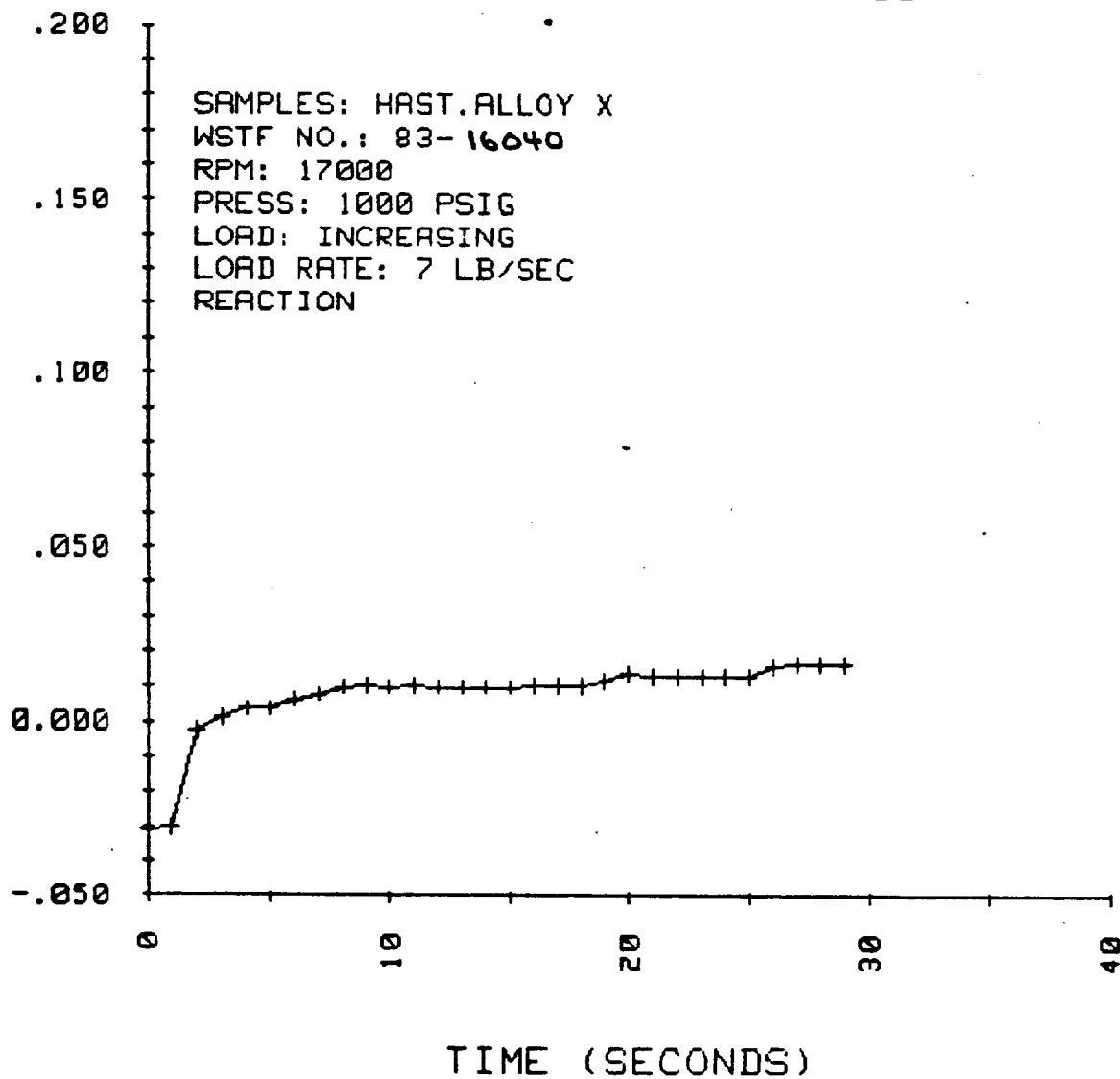
FRT #152 TEST #1 6/20/83

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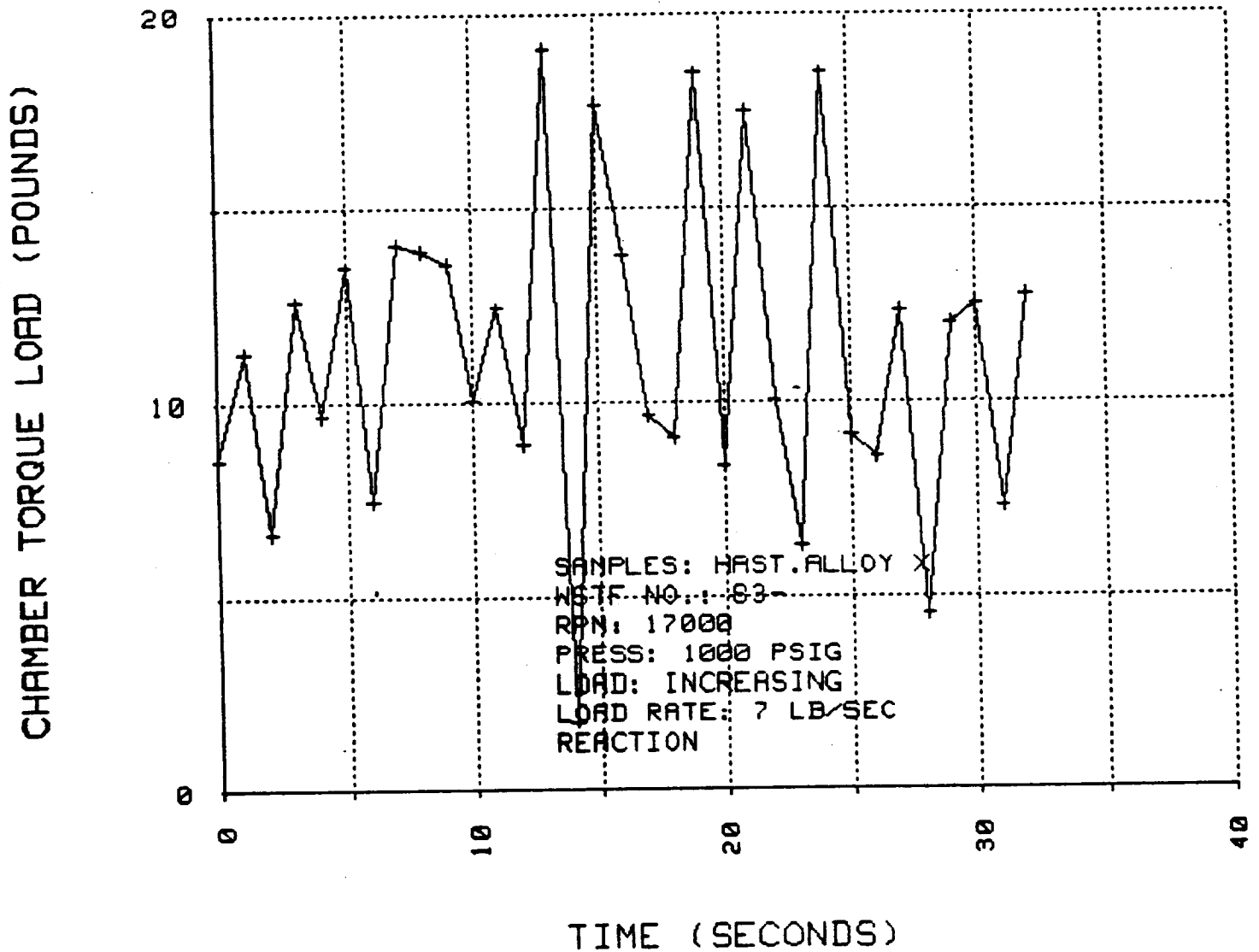


SAMPLE DISPLACEMENT (INCHES)

FRT #152 TEST #1 6/20/83

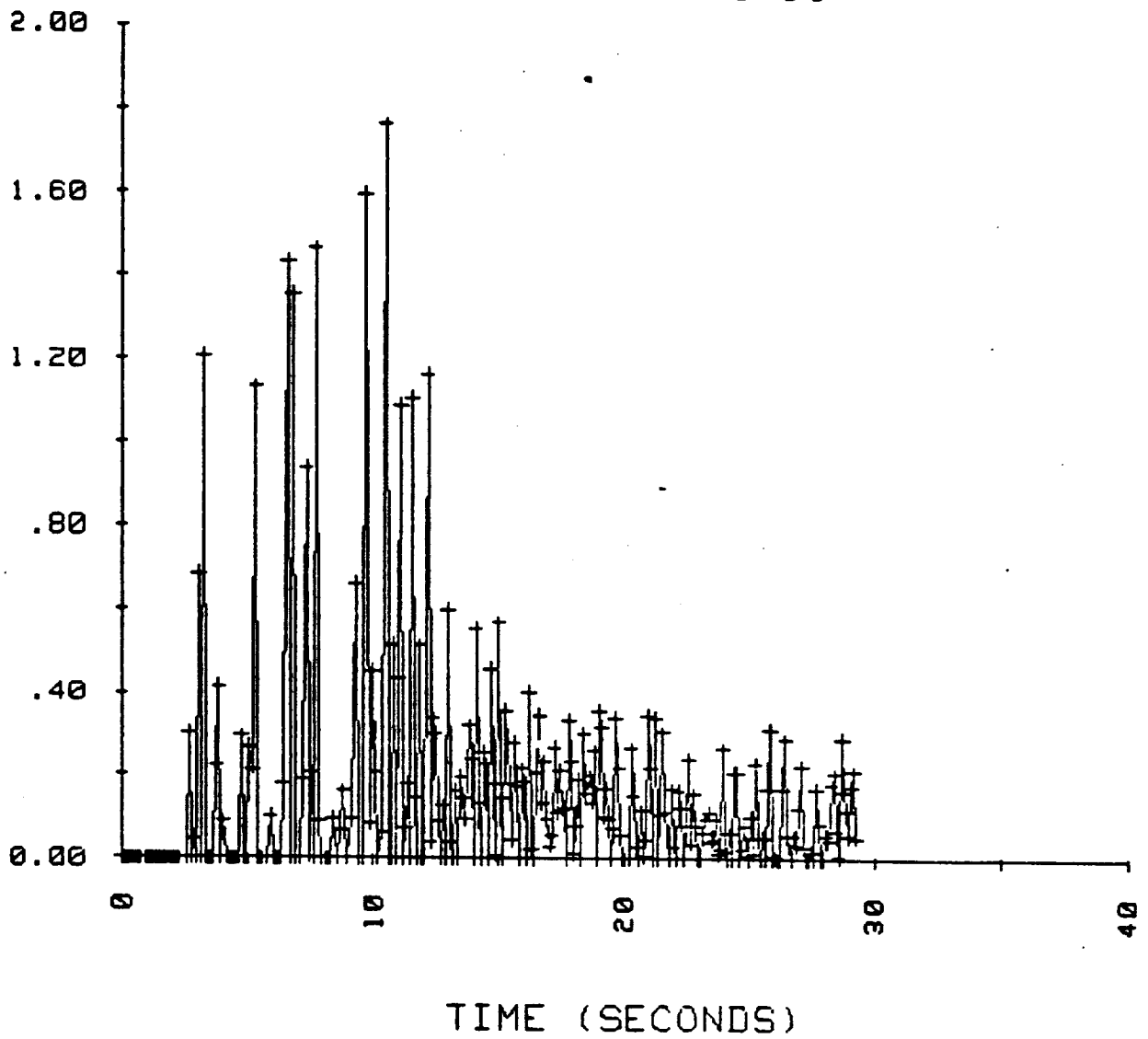


FRT #152 TEST #1 6/20/83



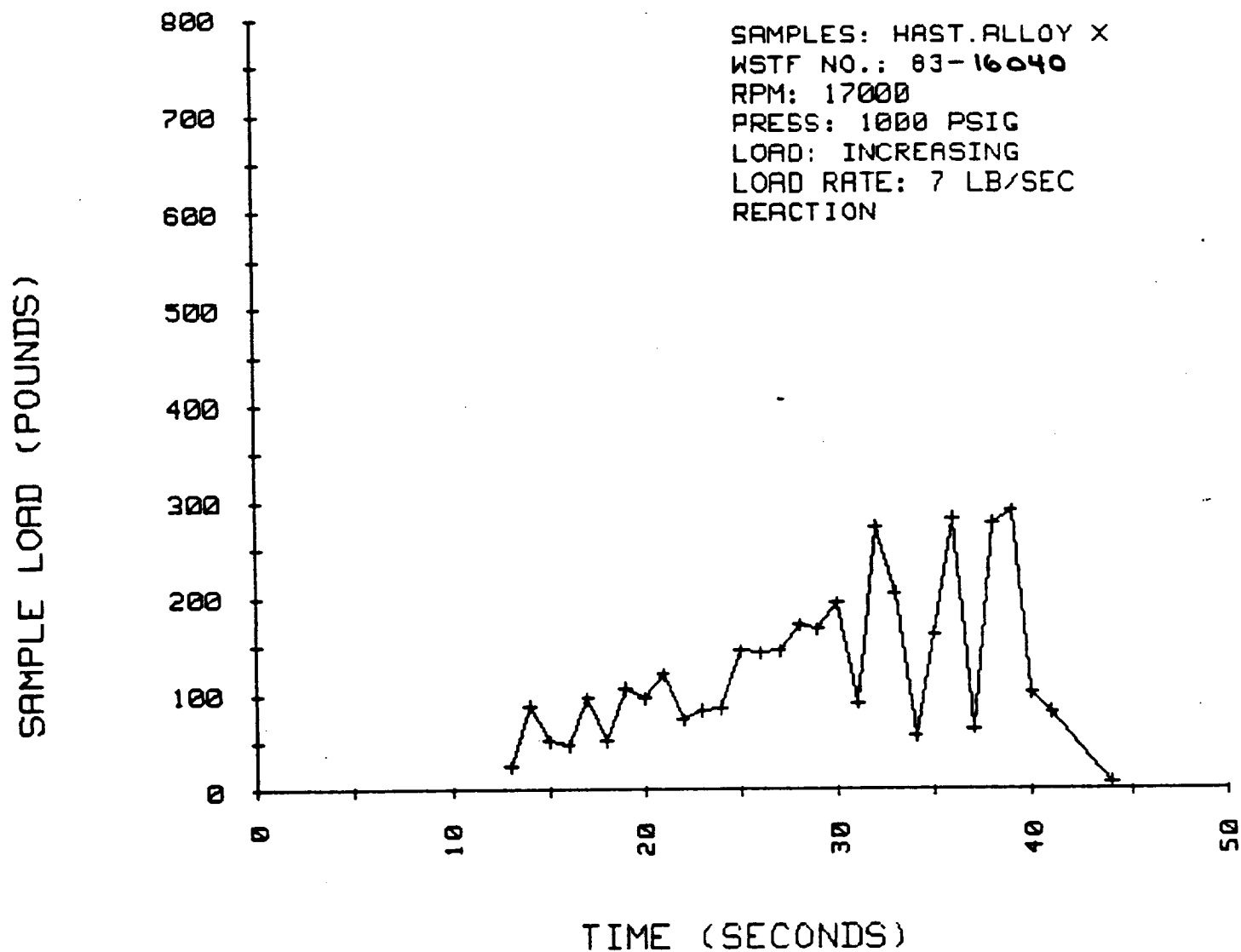
COEFFICIENT OF FRICTION

FRT #152 6/20/83



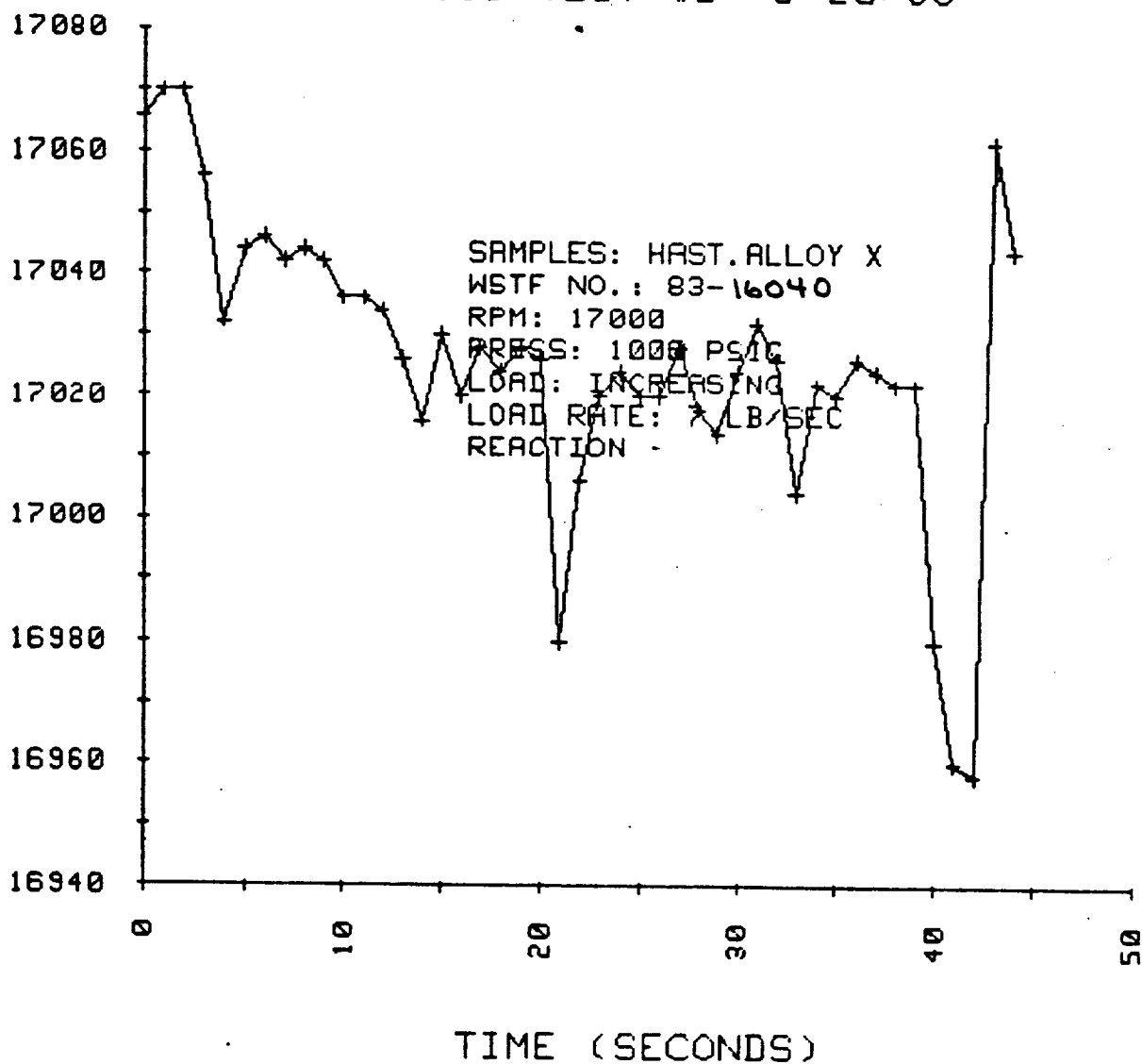
FRT #153 TEST #2 6/20/83

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WSTF NO.: 83-16040
RPM: 17000
PRESS: 1000 PSIG
LOAD: INCREASING
LOAD RATE: 7 LB/SEC
REACTION



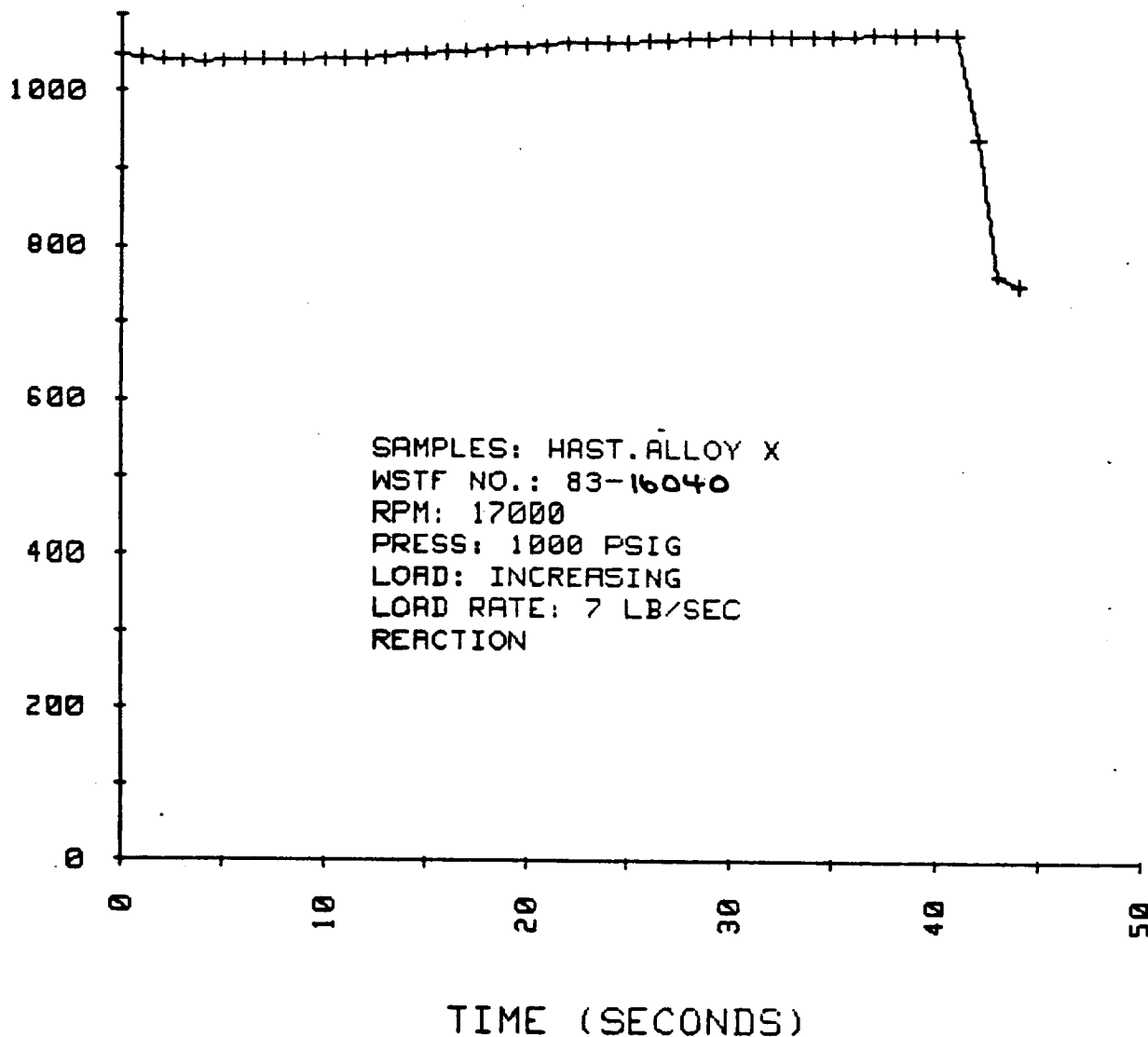
RPM (REVOLUTIONS PER MINUTE)

FRT #153 TEST #2 6/20/83



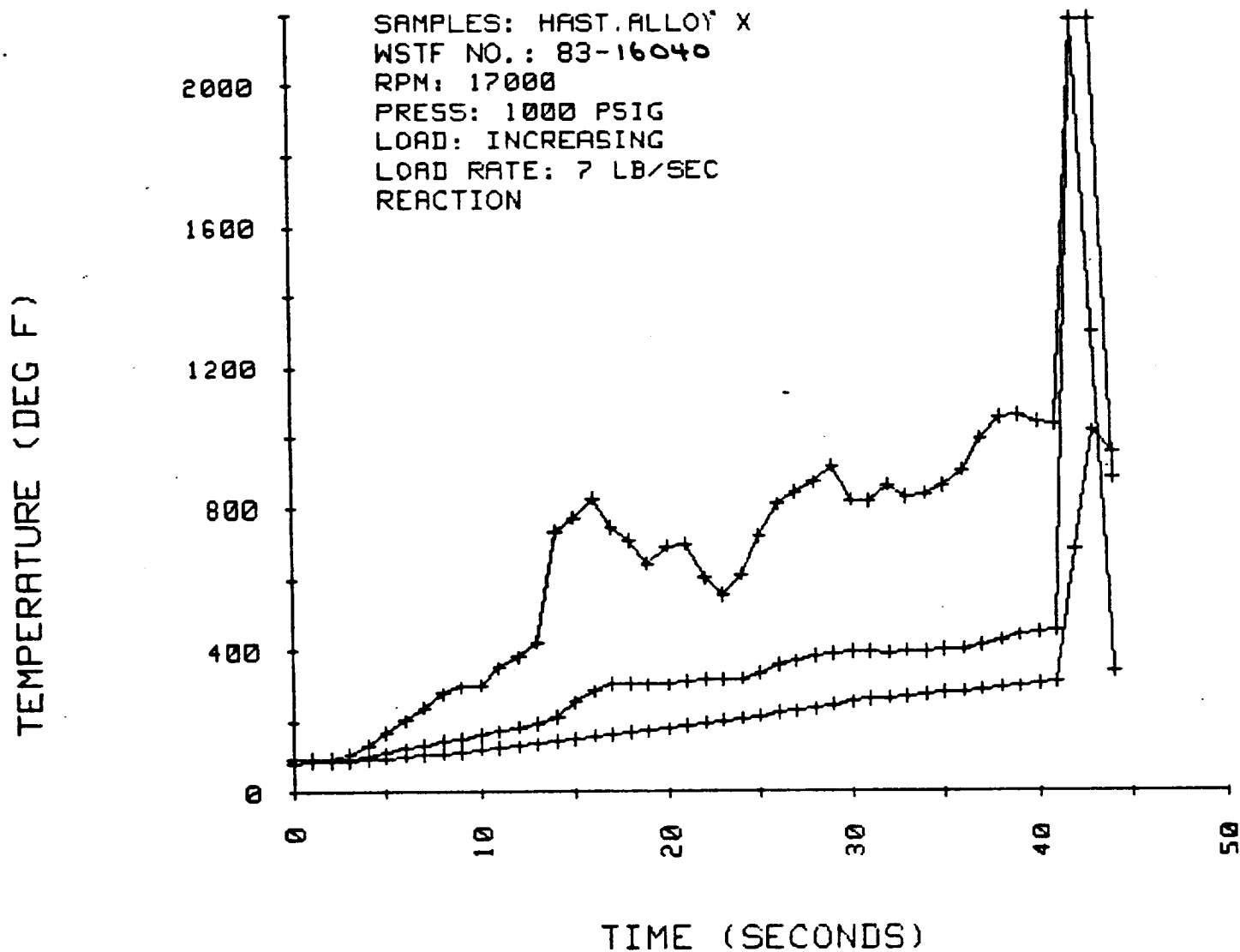
CHAMBER PRESSURE (PSIG)

FRT #153 TEST #2 6/20/83



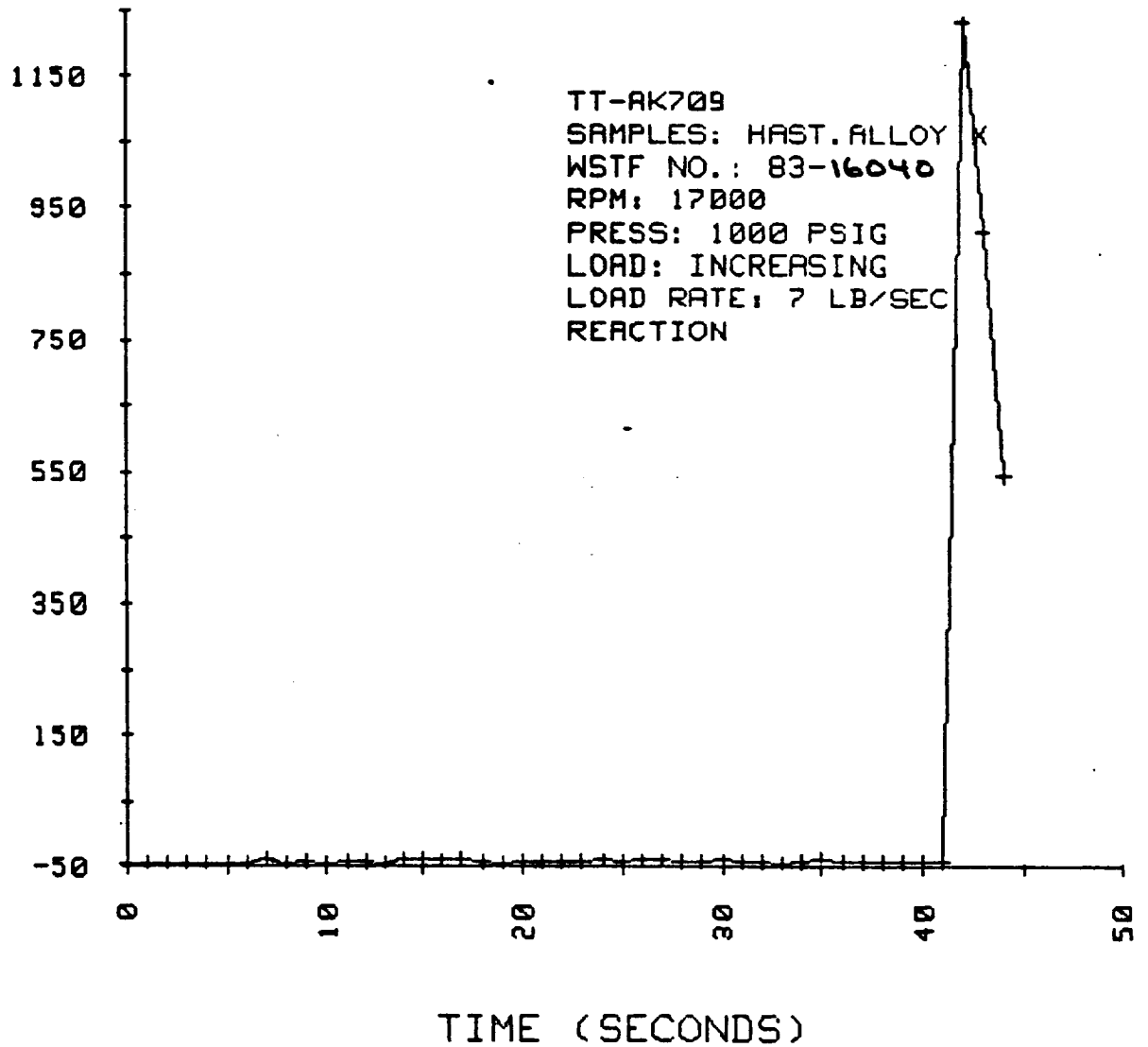
FRT #153 TEST #2 6/20/83

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WSTF NO.: 83-16040
RPM: 17000
PRESS: 1000 PSIG
LOAD: INCREASING
LOAD RATE: 7 LB/SEC
REACTION



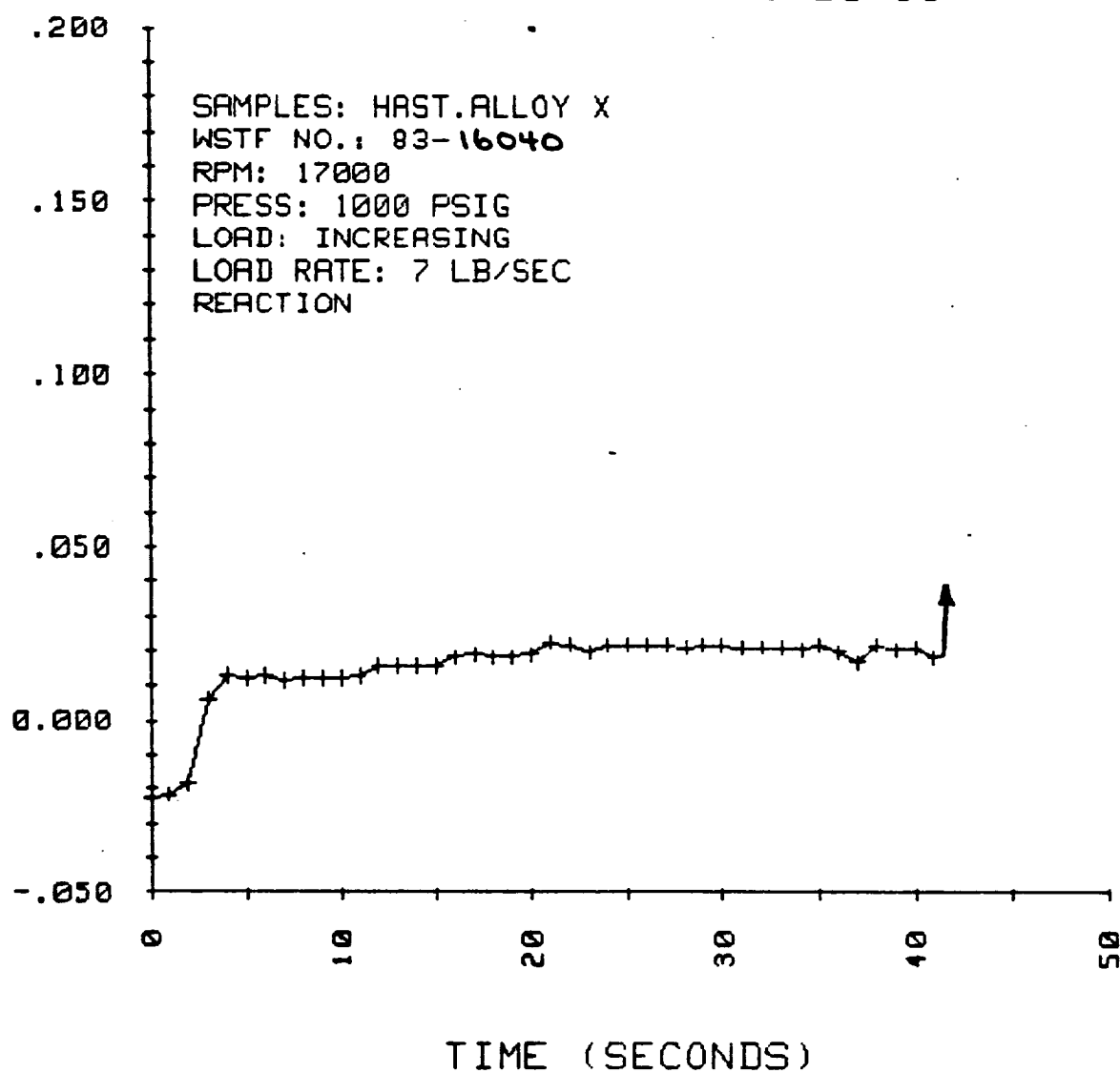
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THERMOPILE OUTPUT (1/100MV)



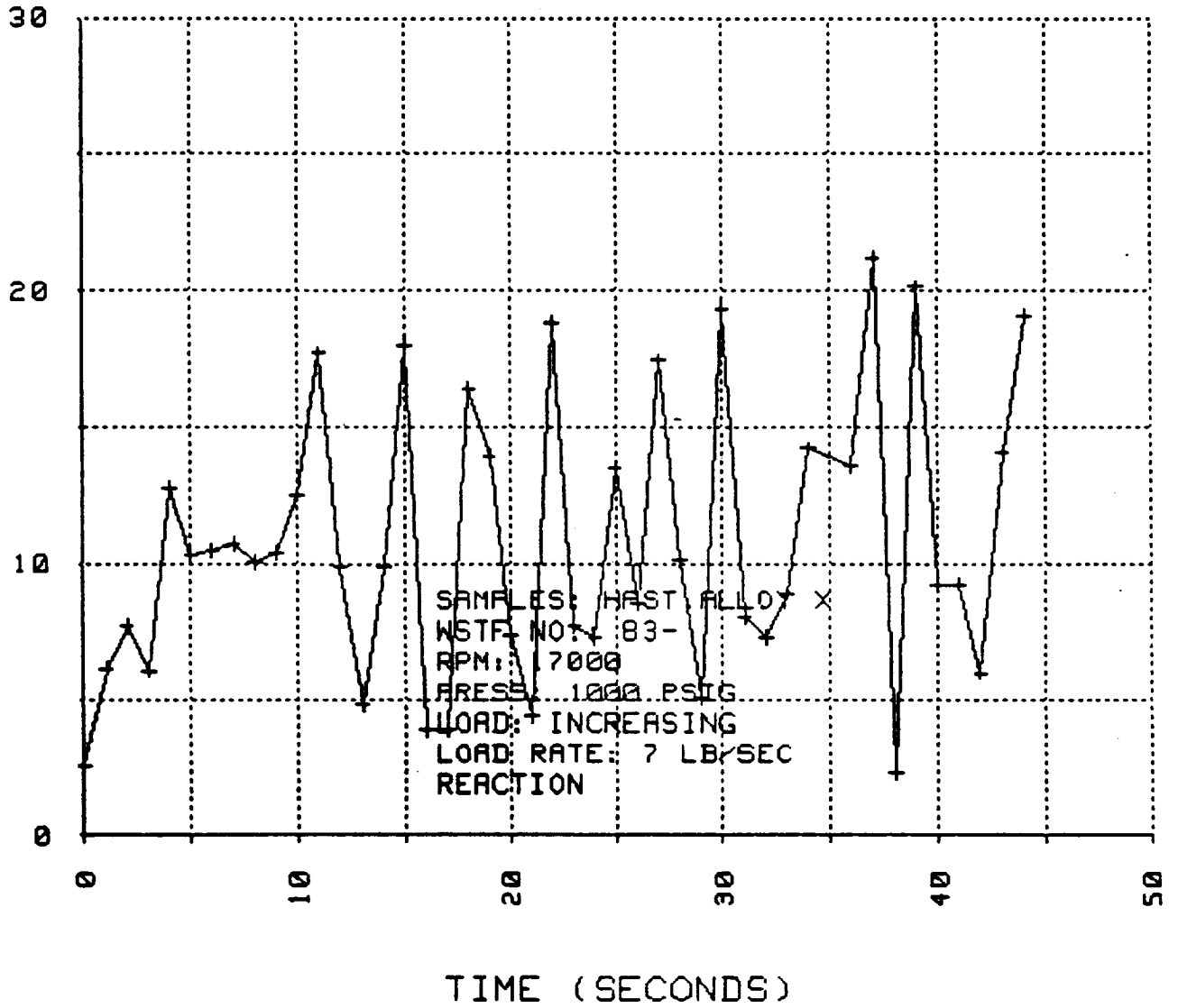
FRT #153 TEST #2 6/20/83

SAMPLE DISPLACEMENT (INCHES)

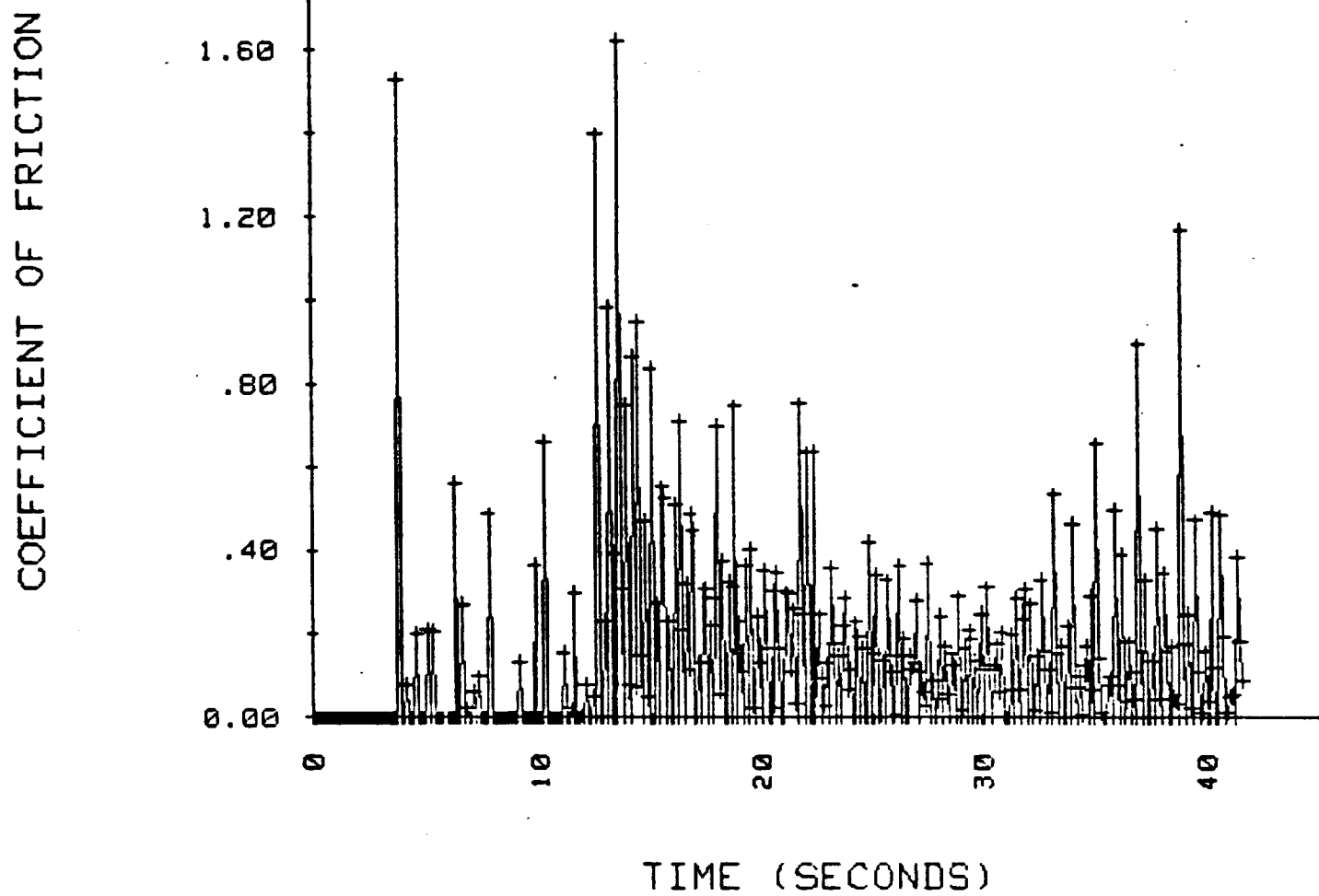


FRT #153 TEST #2 6/20/83

CHAMBER TORQUE LOAD (POUNDS)



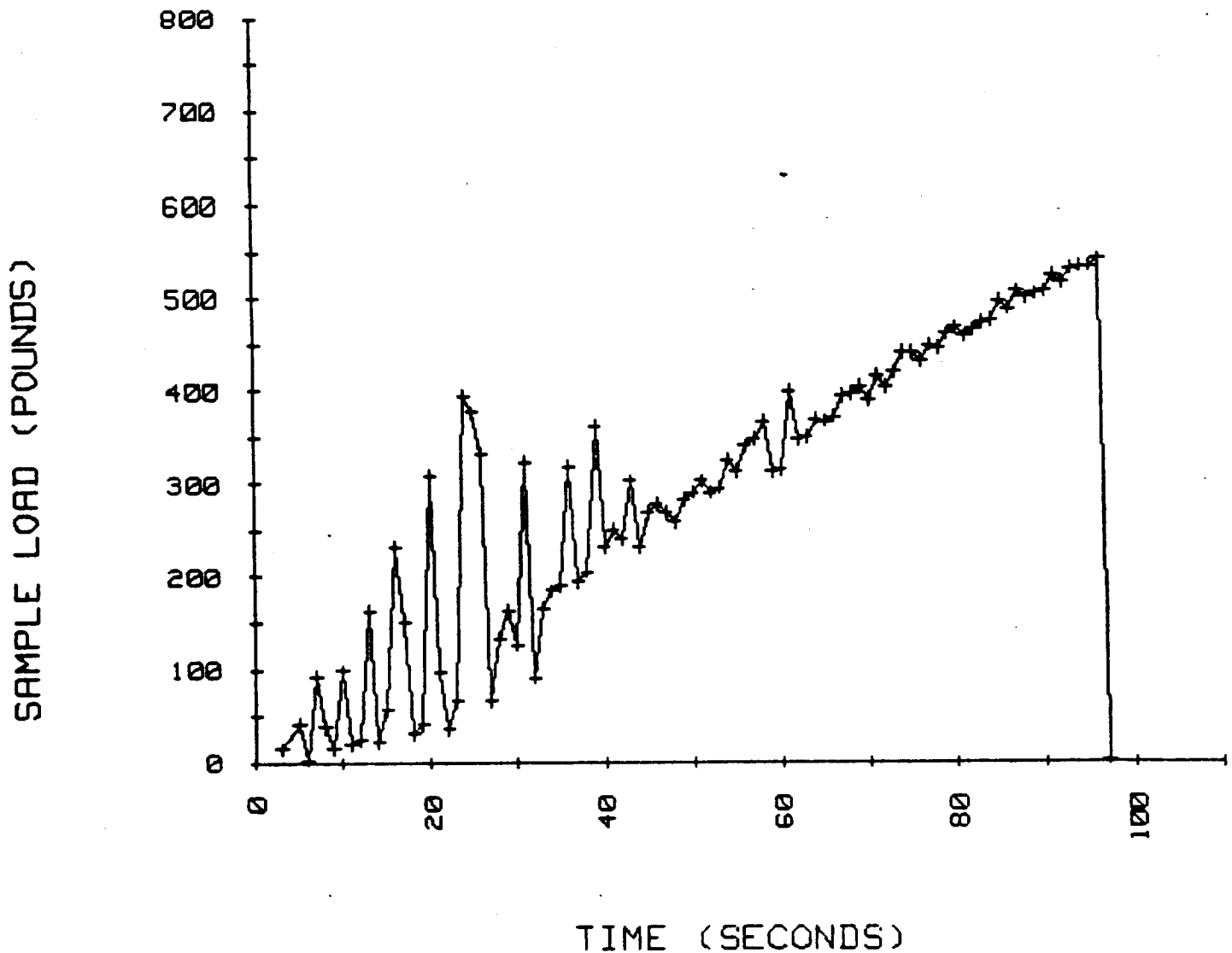
FRT #153 6/21/83



FRT #194

SAMPLES: INCONEL 600
TEST RESULTS: REACTION

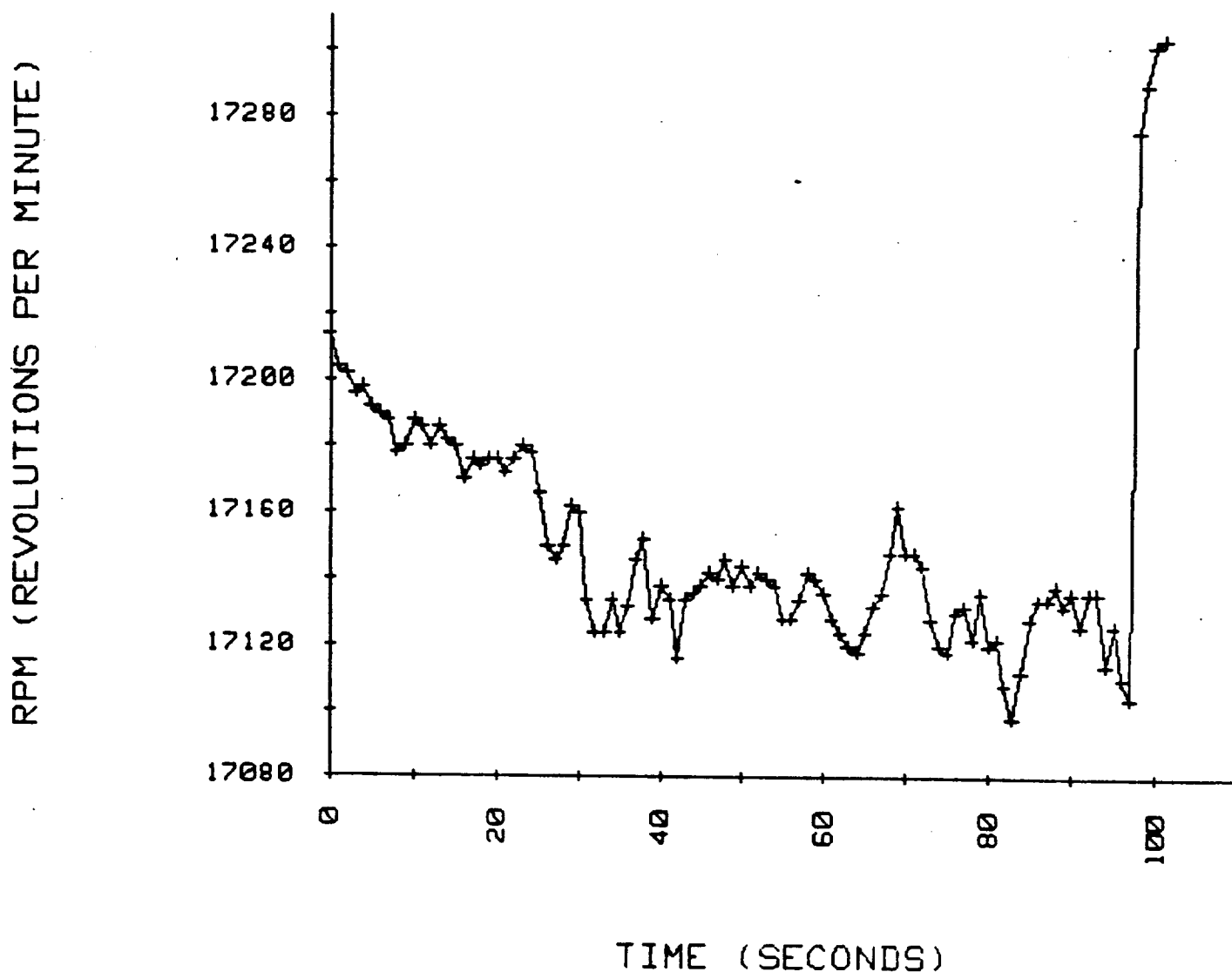
SPEED: 17000 RPM (67 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (24 PSI/SEC)



FRT #194

SAMPLES: INCONEL 600
TEST RESULTS: REACTION

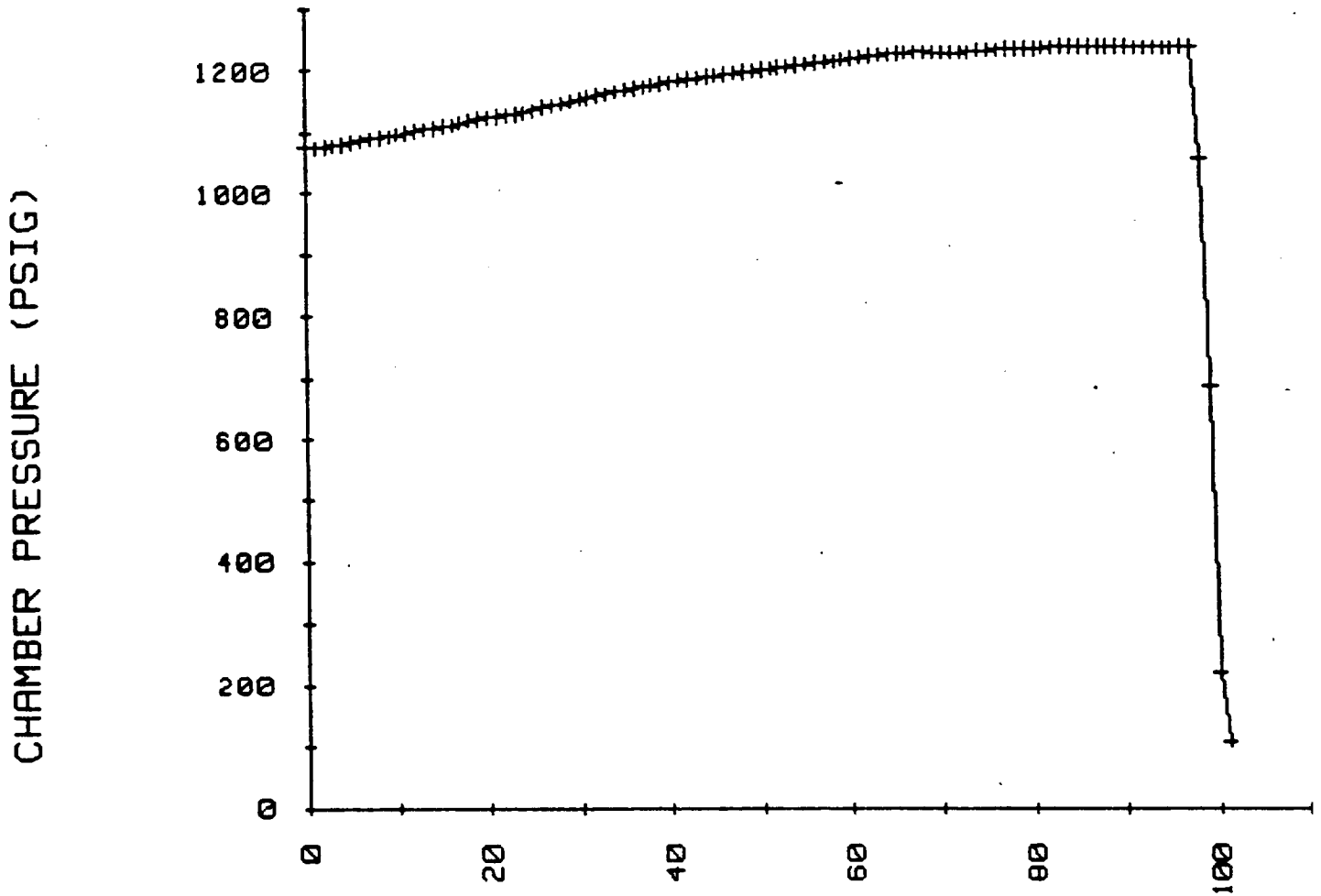
SPEED: 17000 RPM (67 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (24 PSI/SEC)



FRT #194

SAMPLES: INCONEL 600
TEST RESULTS: REACTION

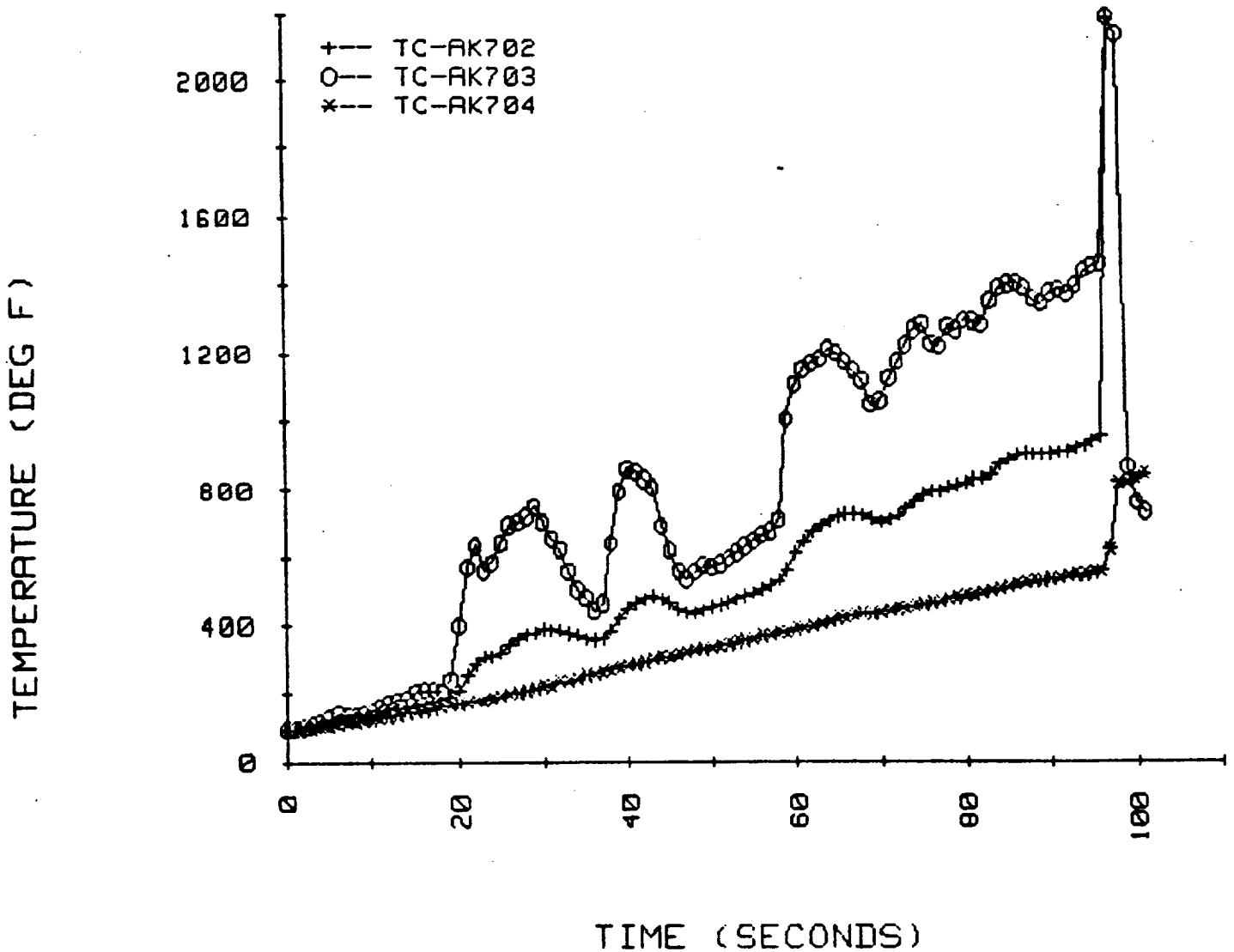
SPEED: 17000 RPM (67 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (24 PSI/SEC)



FRT #194

SAMPLES: INCONEL 600
TEST RESULTS: REACTION

SPEED: 17000 RPM (67 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (24 PSI/SEC)

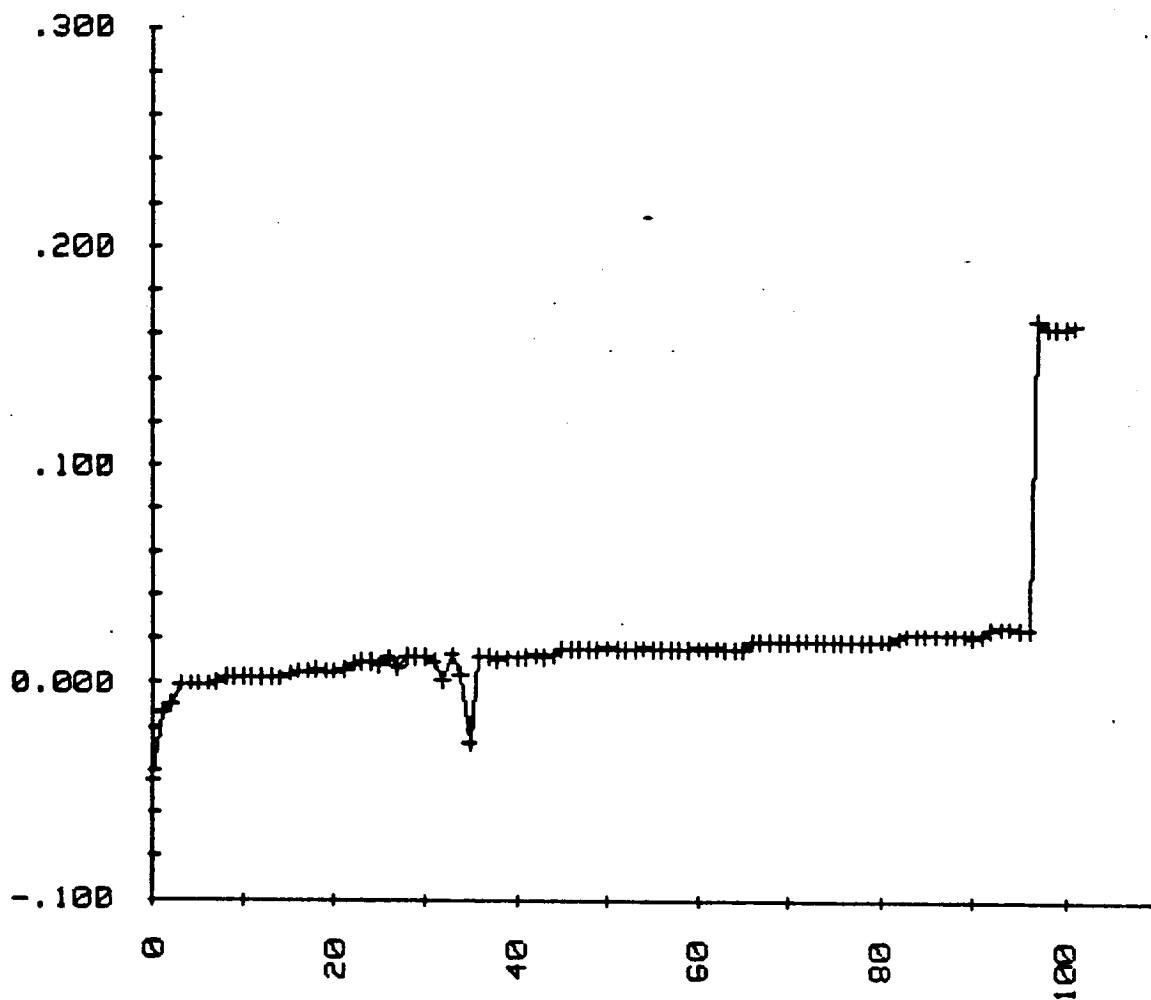


FRT #194

SAMPLES: INCONEL 600
TEST RESULTS: REACTION

SPEED: 17000 RPM (67 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (24 PSI/SEC)

SAMPLE DISPLACEMENT (INCHES)

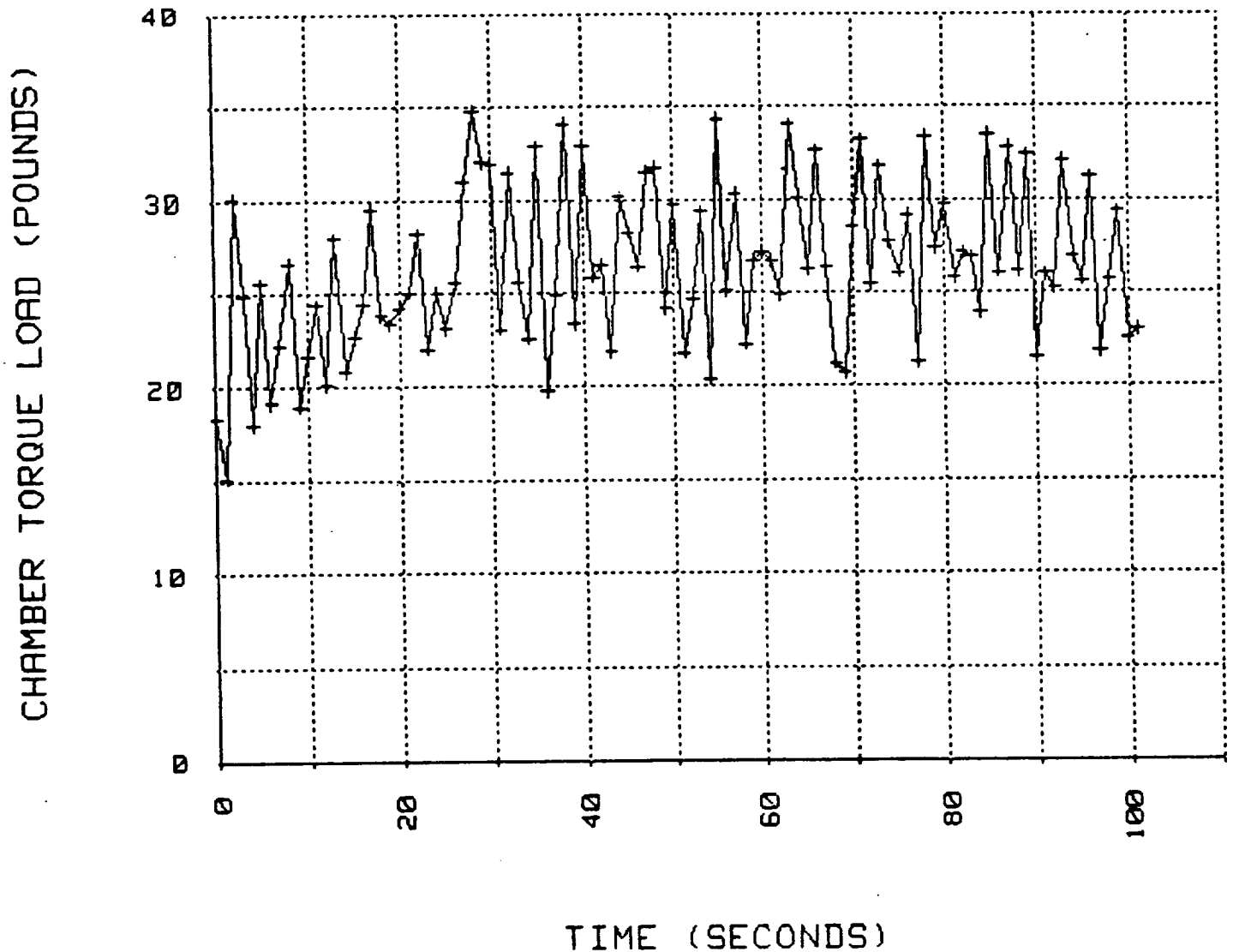


TIME (SECONDS)

FRT #194

SAMPLES: INCONEL 600
TEST RESULTS: REACTION

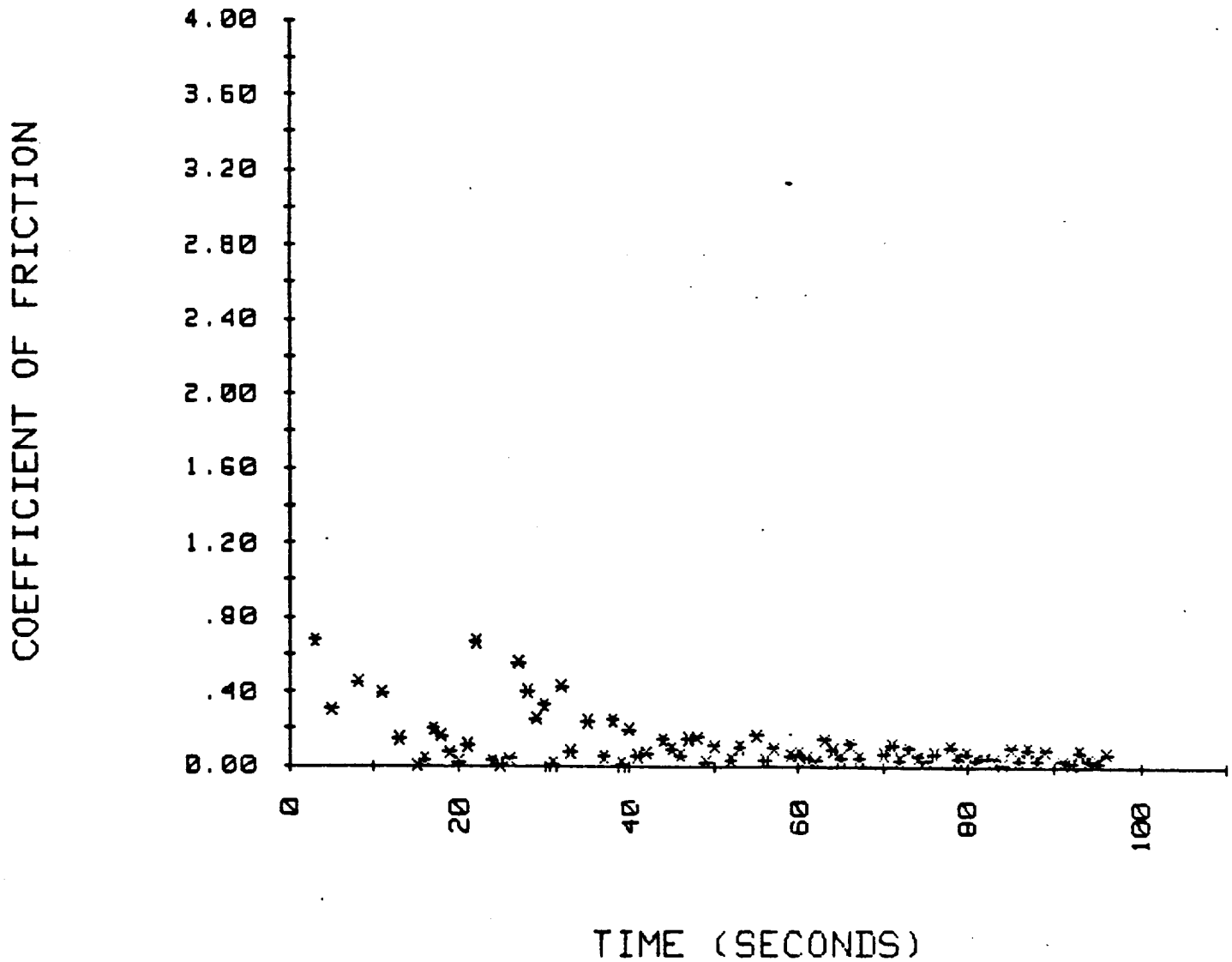
SPEED: 17000 RPM (67 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (24 PSI/SEC)



FRT #194

SAMPLES: INCONEL 600
TEST RESULTS: REACTION

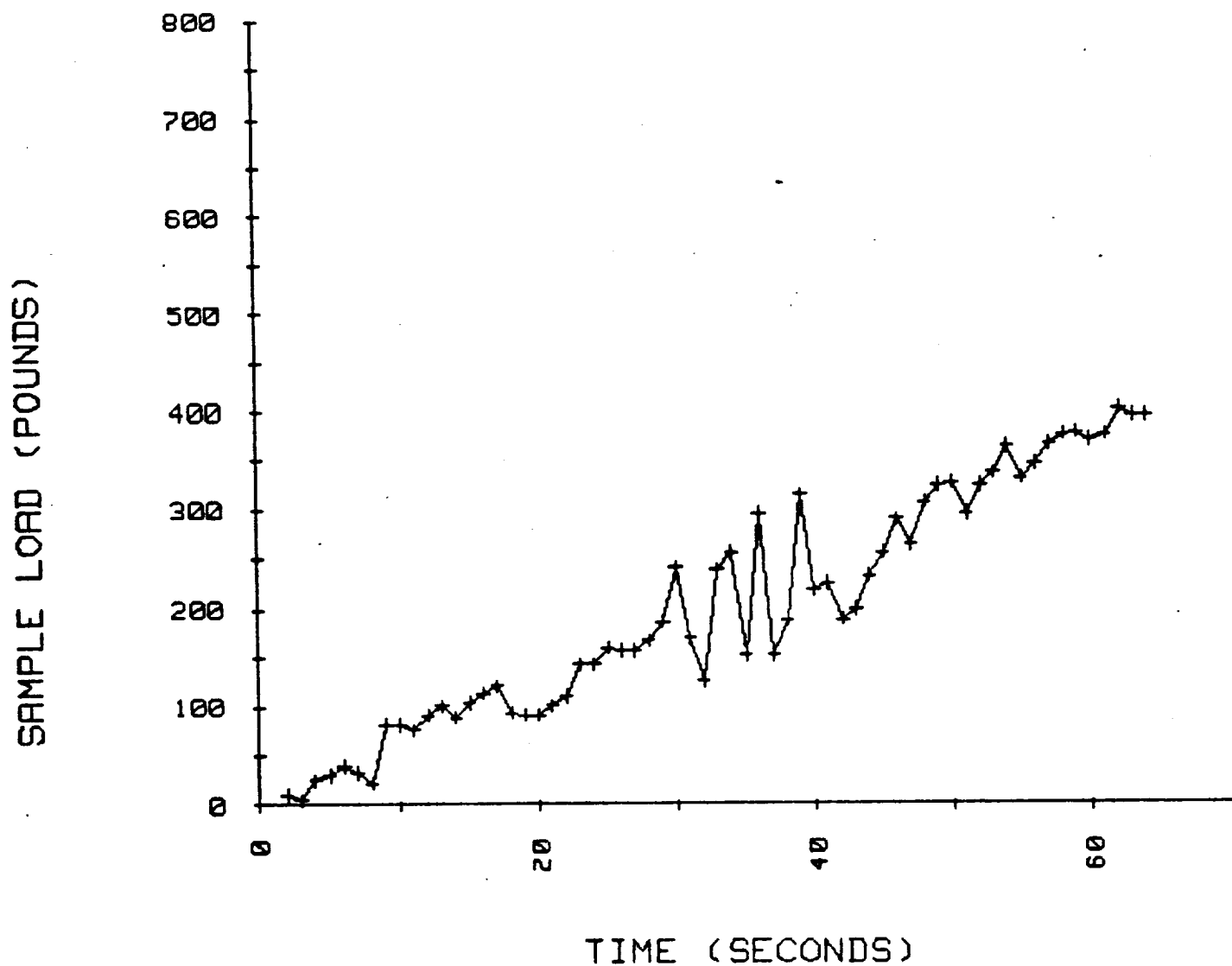
SPEED: 17000 RPM (67 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (24 PSI/SEC)



FRT #195

SAMPLES: INCONEL 600
TEST RESULTS: REACTION

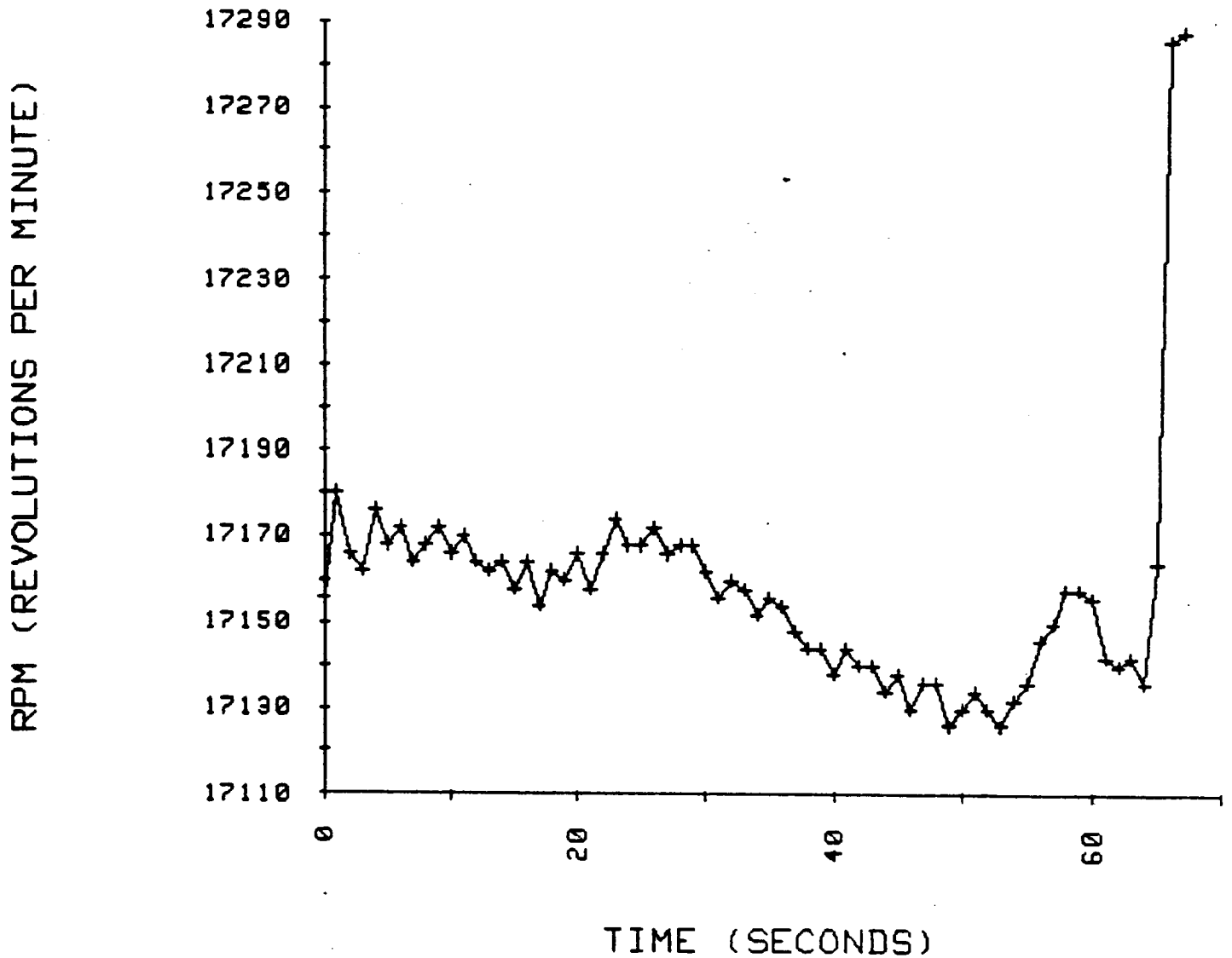
SPEED: 17000 RPM (67 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (24 PSI/SEC)



FRT #195

SAMPLES: INCONEL 600
TEST RESULTS: REACTION

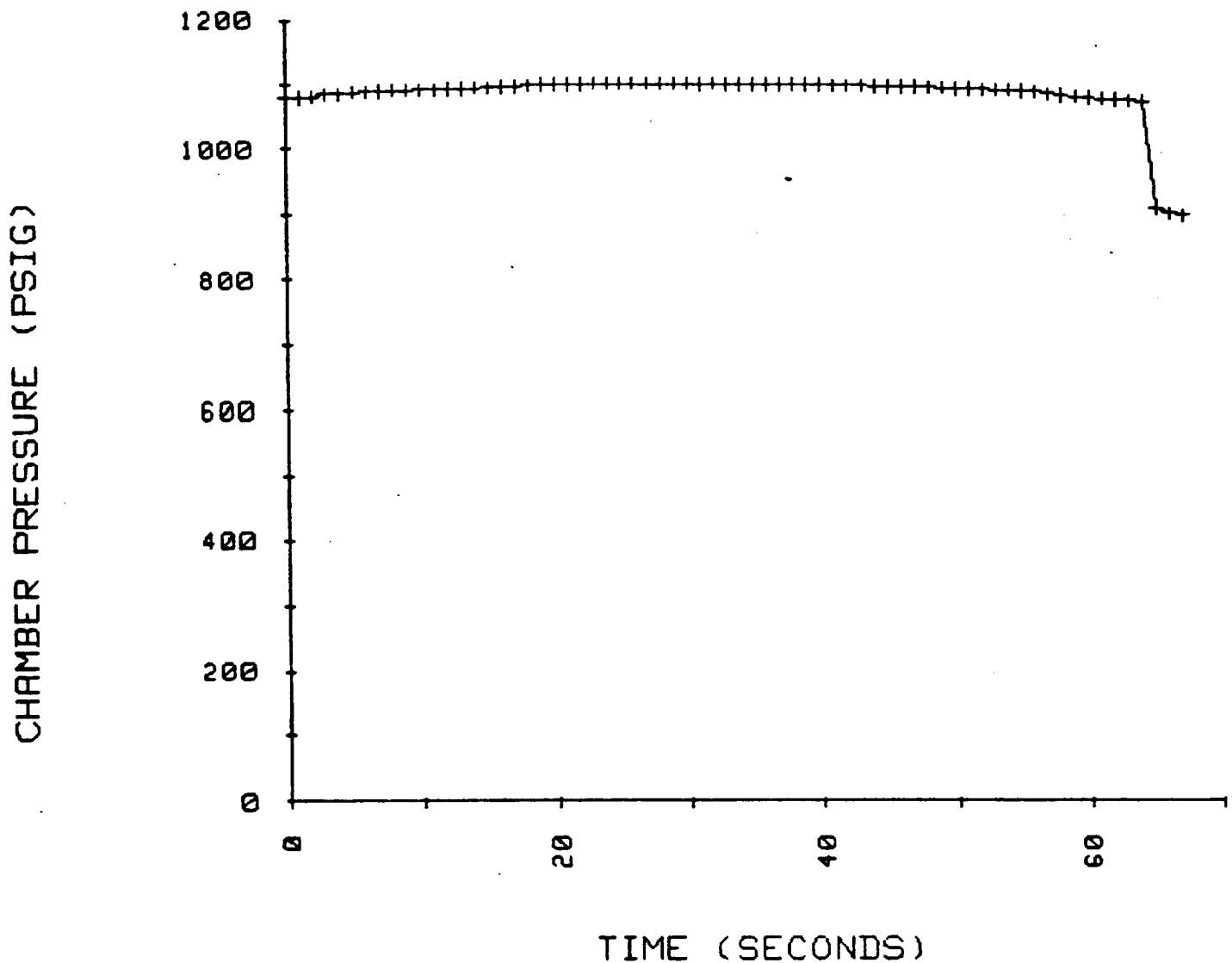
SPEED: 17000 RPM (67 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (24 PSI/SEC)



FRT #195

SAMPLES: INCONEL 600
TEST RESULTS: REACTION

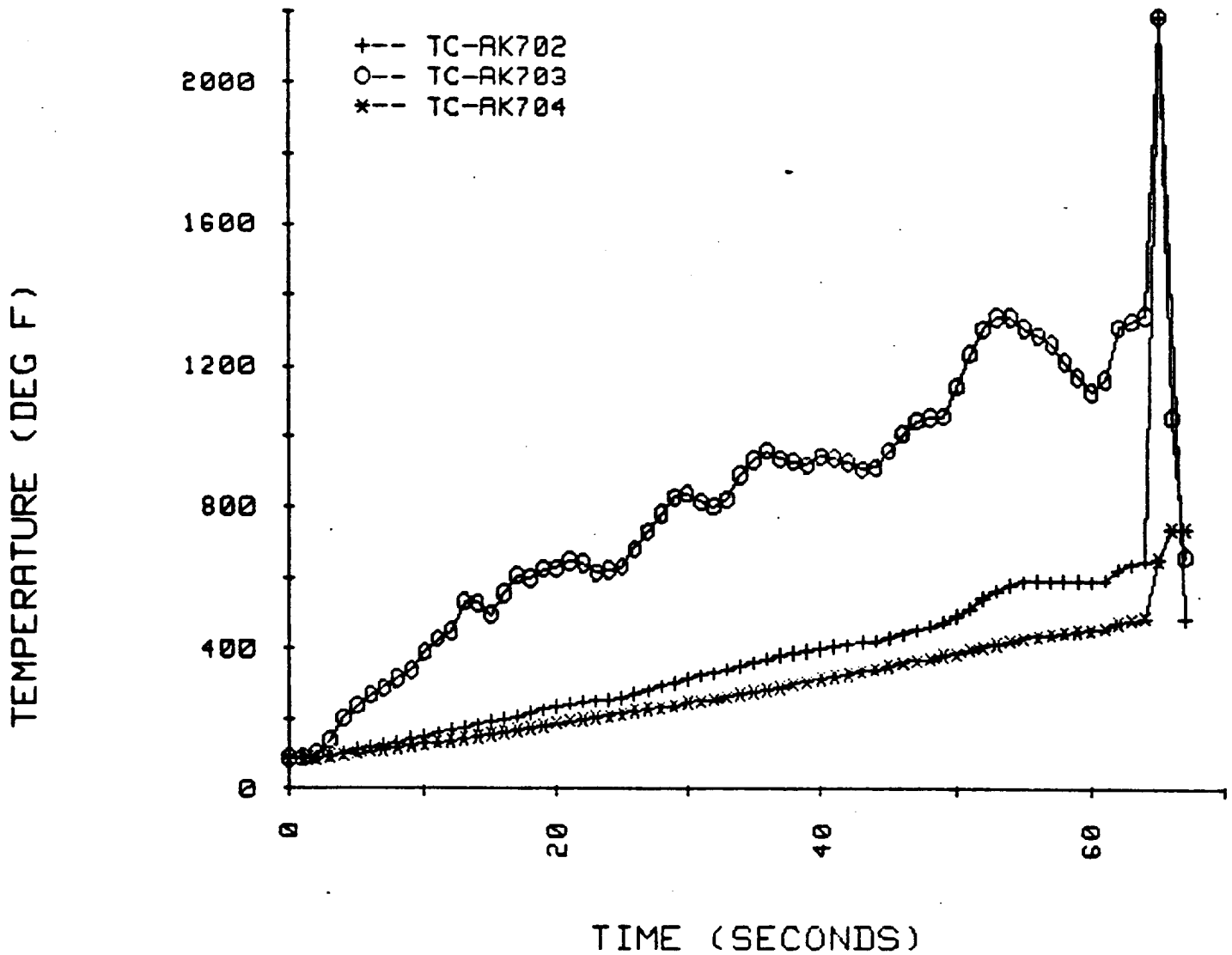
SPEED: 17000 RPM (67 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (24 PSI/SEC)



FRT #195

SAMPLES: INCONEL 600
TEST RESULTS: REACTION

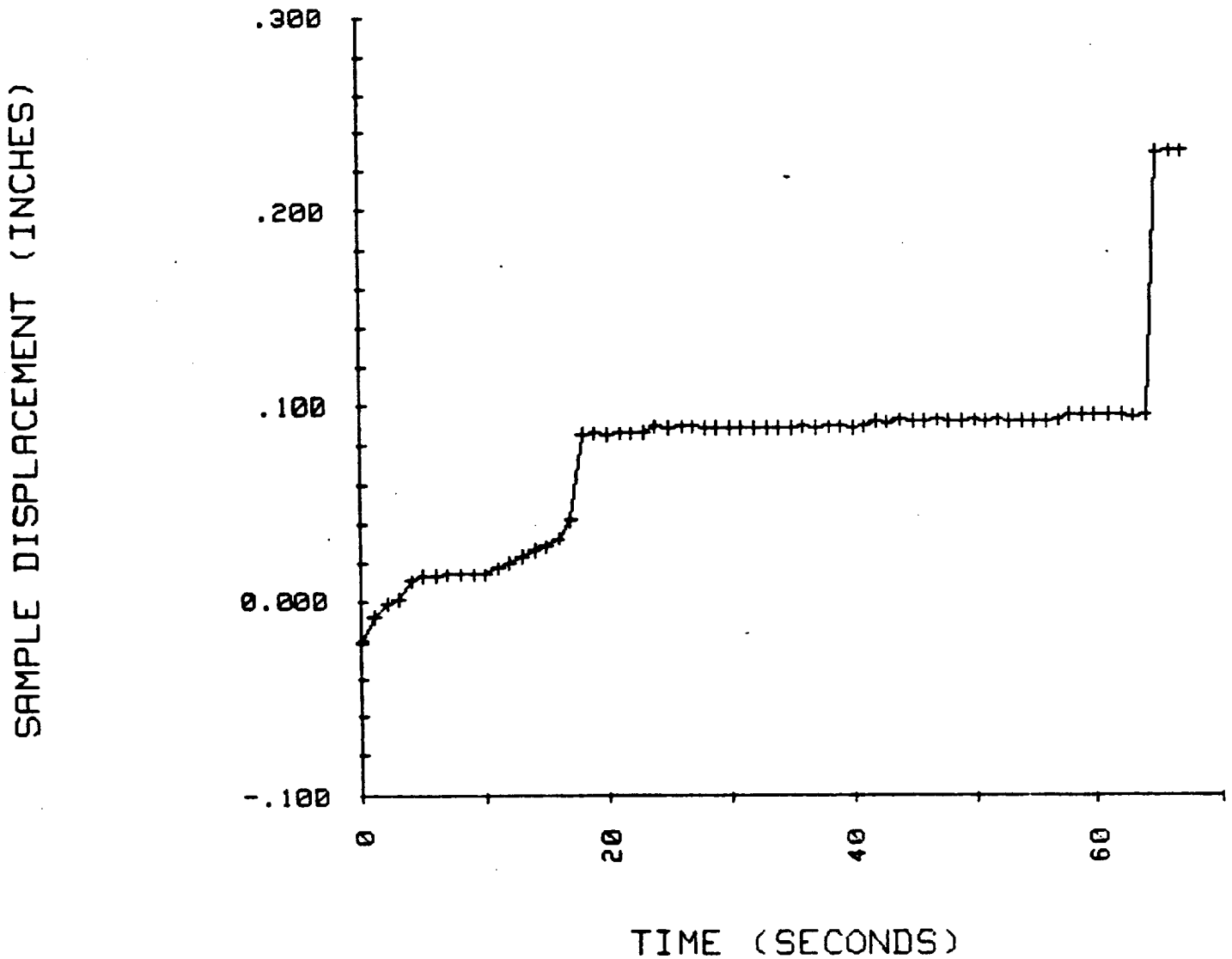
SPEED: 17000 RPM (67 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (24 PSI/SEC)



FRT #195

SAMPLES: INCONEL 600
TEST RESULTS: REACTION

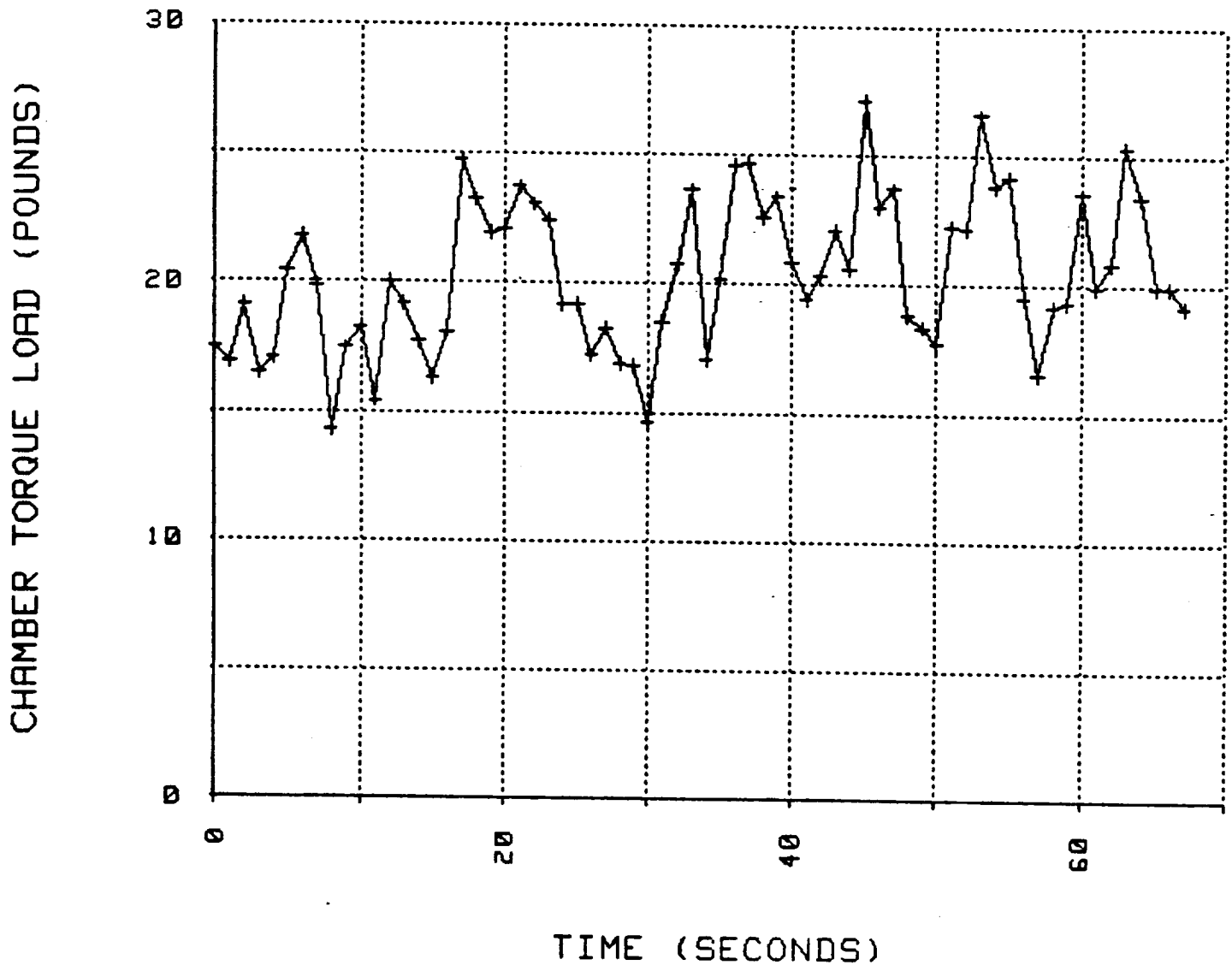
SPEED: 17000 RPM (67 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (24 PSI/SEC)



FRT #195

SAMPLES: INCONEL 600
TEST RESULTS: REACTION

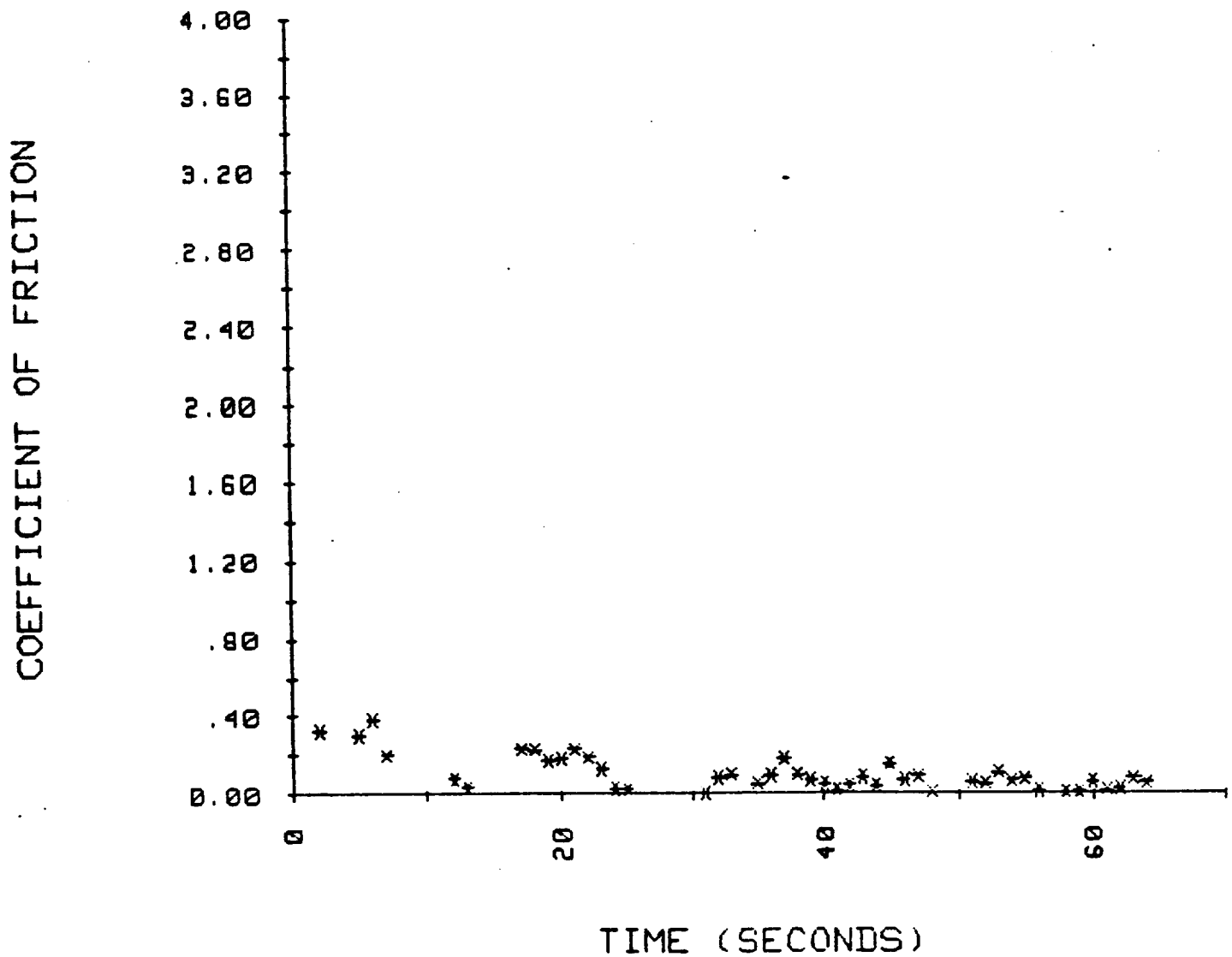
SPEED: 17000 RPM (67 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (24 PSI/SEC)



FRT #195

SAMPLES: INCONEL 600
TEST RESULTS: REACTION

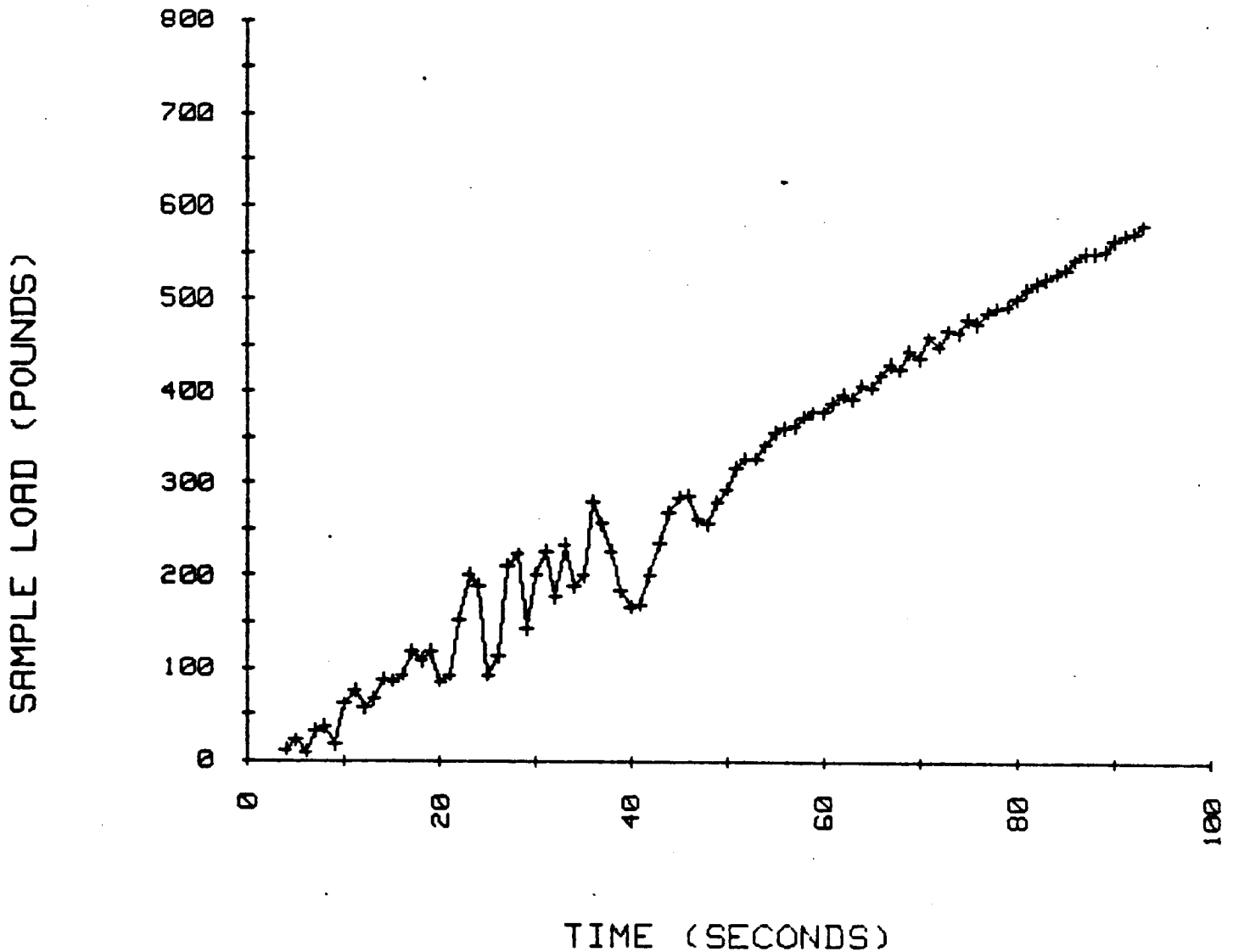
SPEED: 17000 RPM (67 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (24 PSI/SEC)



FRT #196

SAMPLES: INCONEL 600
TEST RESULTS: REACTION

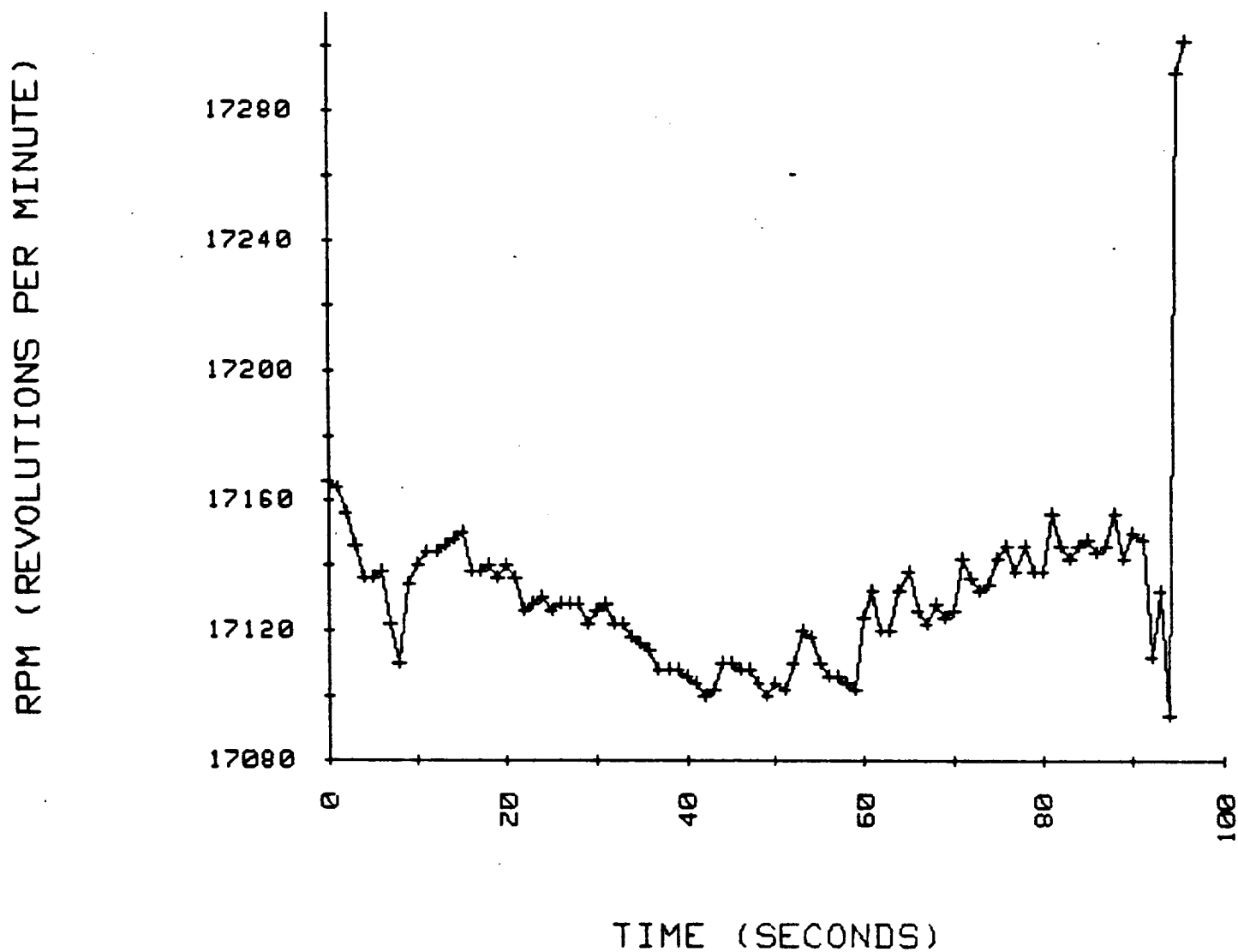
SPEED: 17000 RPM (67 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (24 PSI/SEC)



FRT #196

SAMPLES: INCONEL 600
TEST RESULTS: REACTION

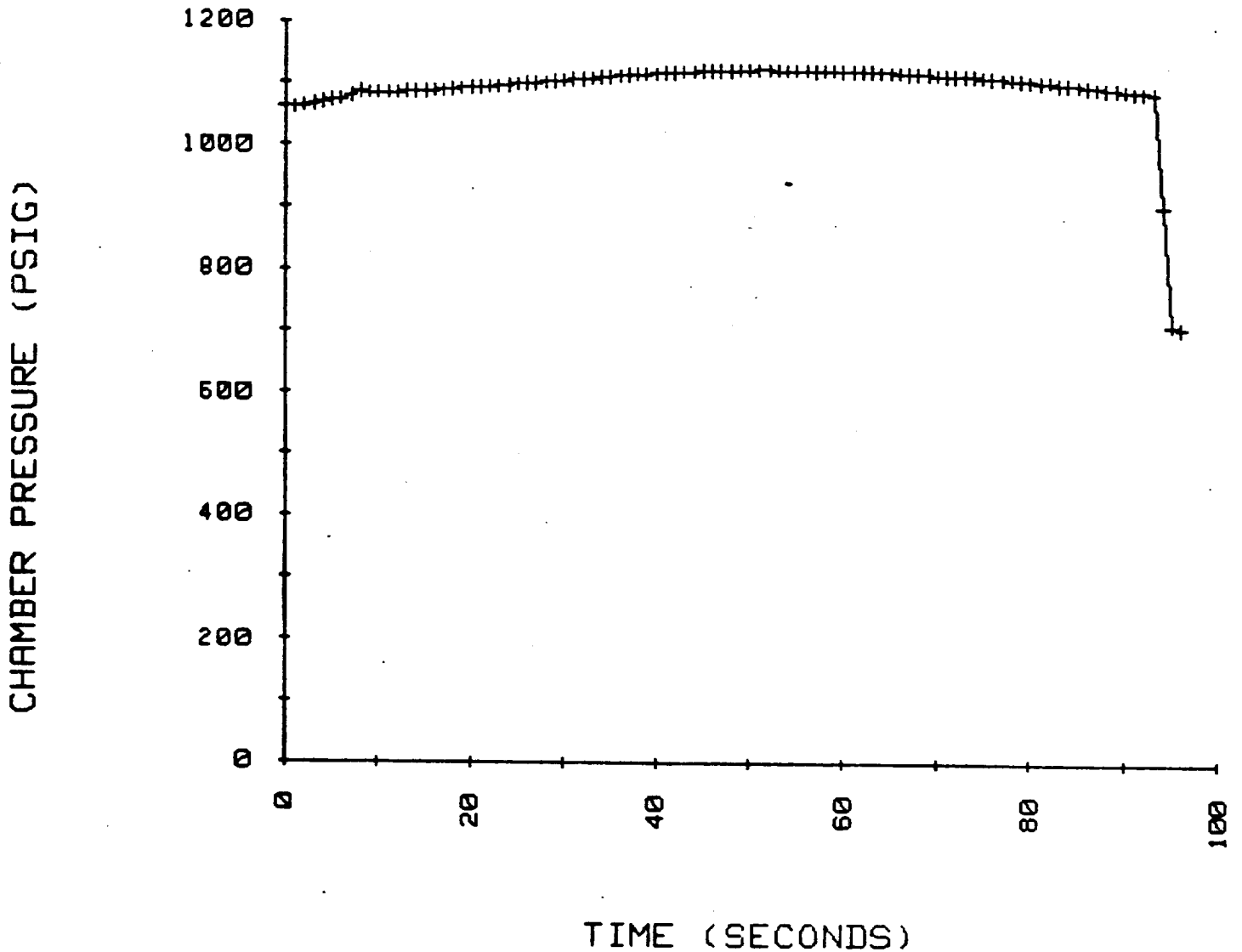
SPEED: 17000 RPM (67 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (24 PSI/SEC)



FRT #196

SAMPLES: INCONEL 600
TEST RESULTS: REACTION

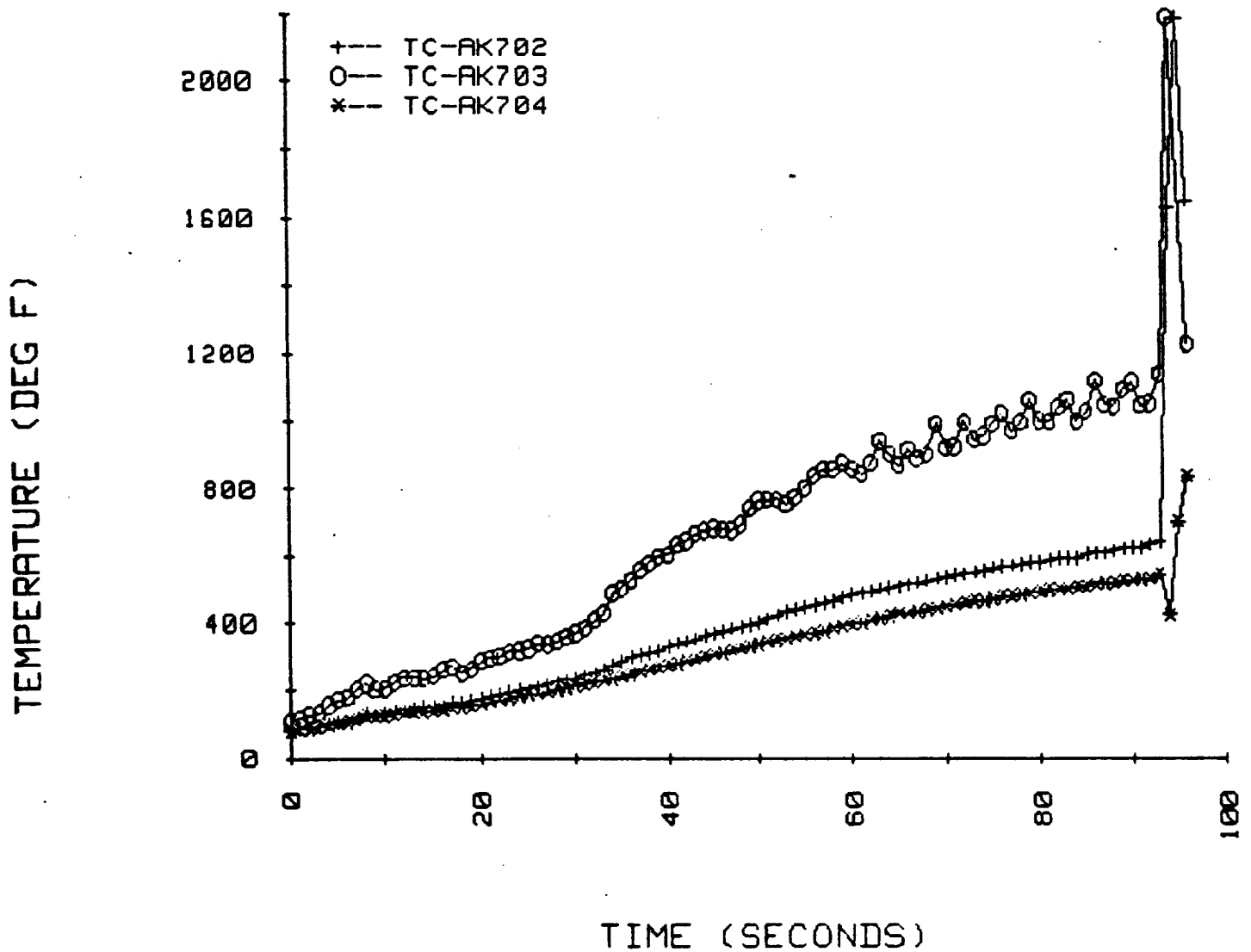
SPEED: 17000 RPM (67 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (24 PSI/SEC)



FRT #196

SAMPLES: INCONEL 600
TEST RESULTS: REACTION

SPEED: 17000 RPM (67 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (24 PSI/SEC)

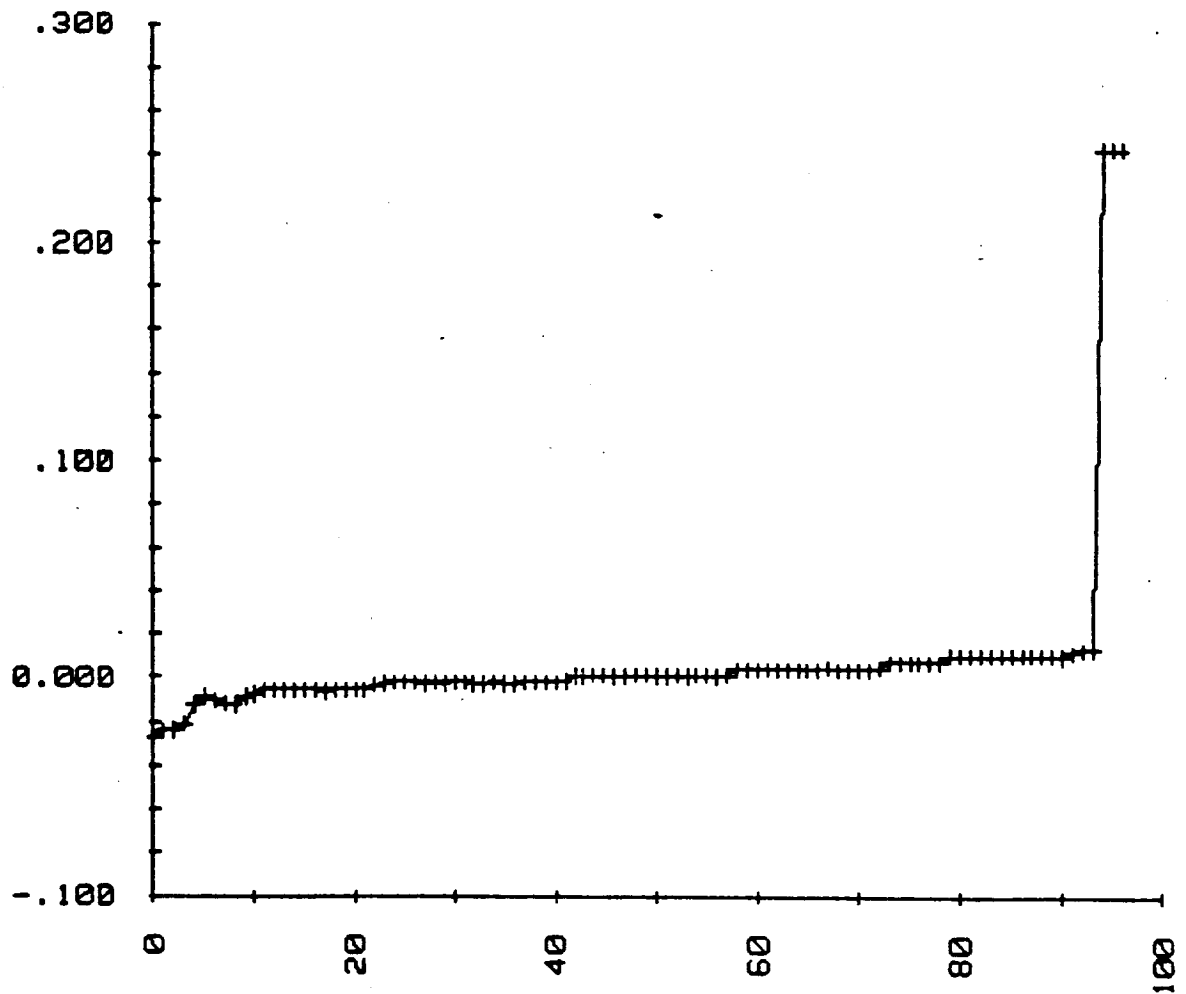


FRT #196

SAMPLES: INCONEL 600
TEST RESULTS: REACTION

SPEED: 17000 RPM (67 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (24 PSI/SEC)

SAMPLE DISPLACEMENT (INCHES)

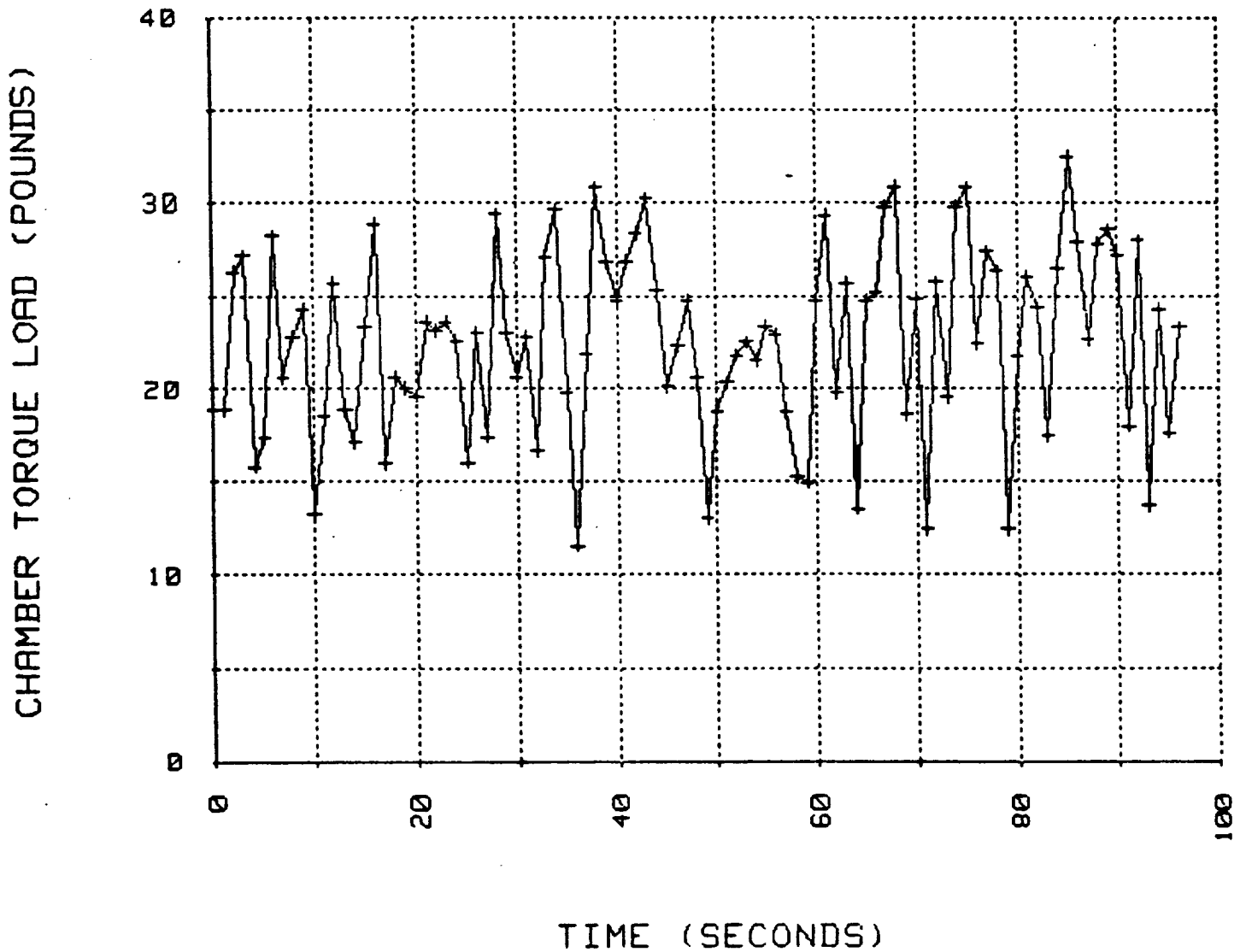


TIME (SECONDS)

FRT #196

SAMPLES: INCONEL 600
TEST RESULTS: REACTION

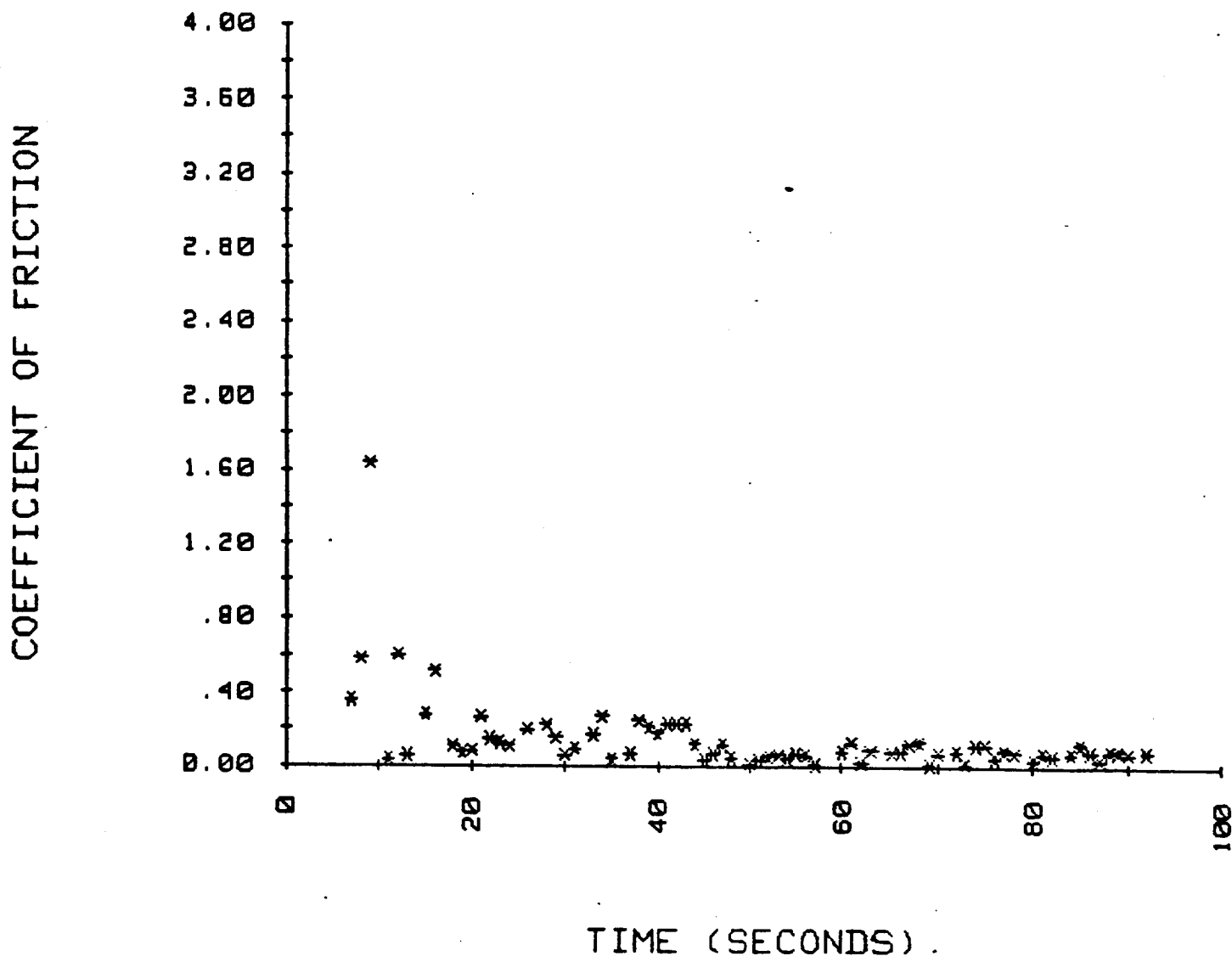
SPEED: 17000 RPM (67 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (24 PSI/SEC)



FRT #196

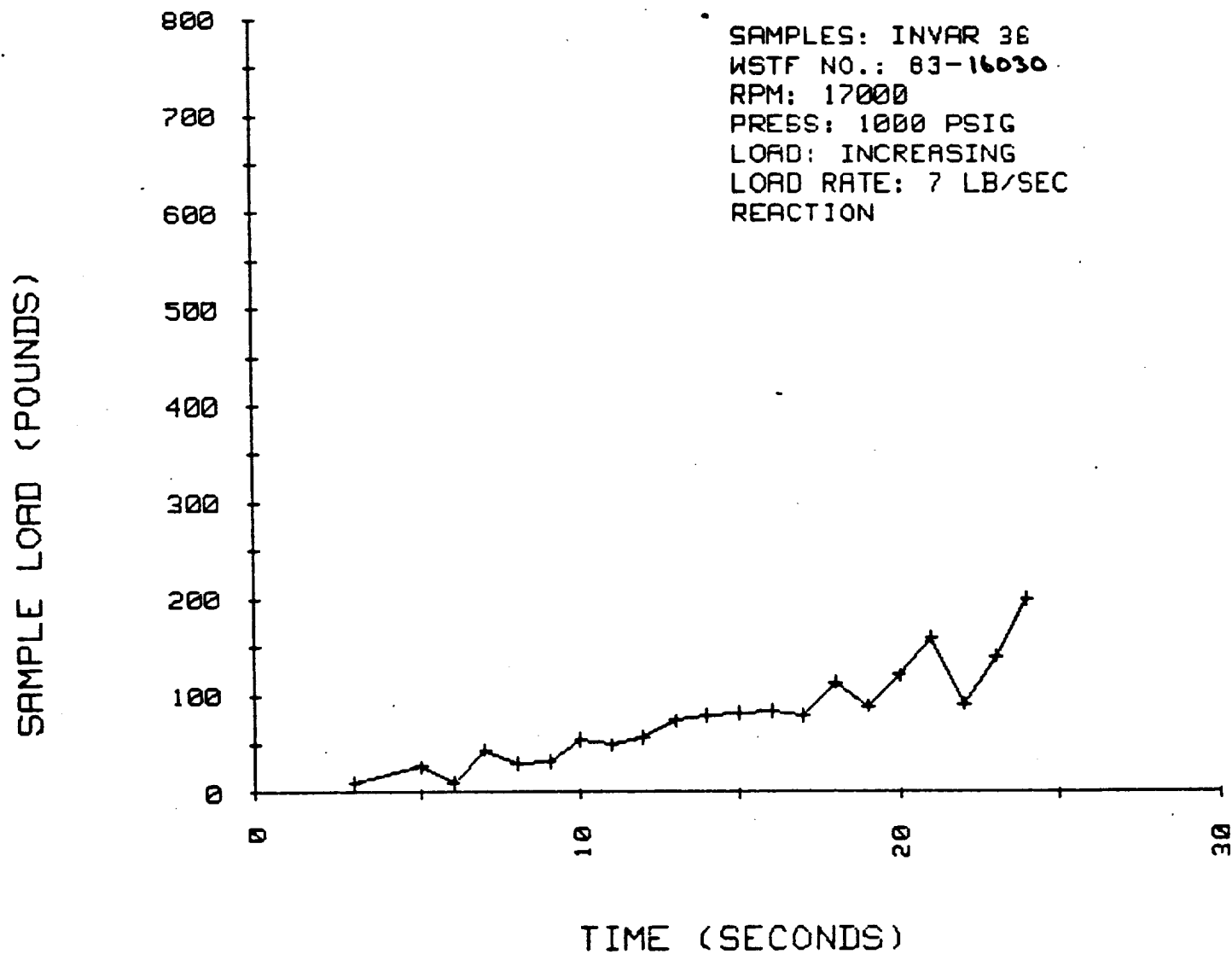
SAMPLES: INCONEL 600
TEST RESULTS: REACTION

SPEED: 17000 RPM (67 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (24 PSI/SEC)



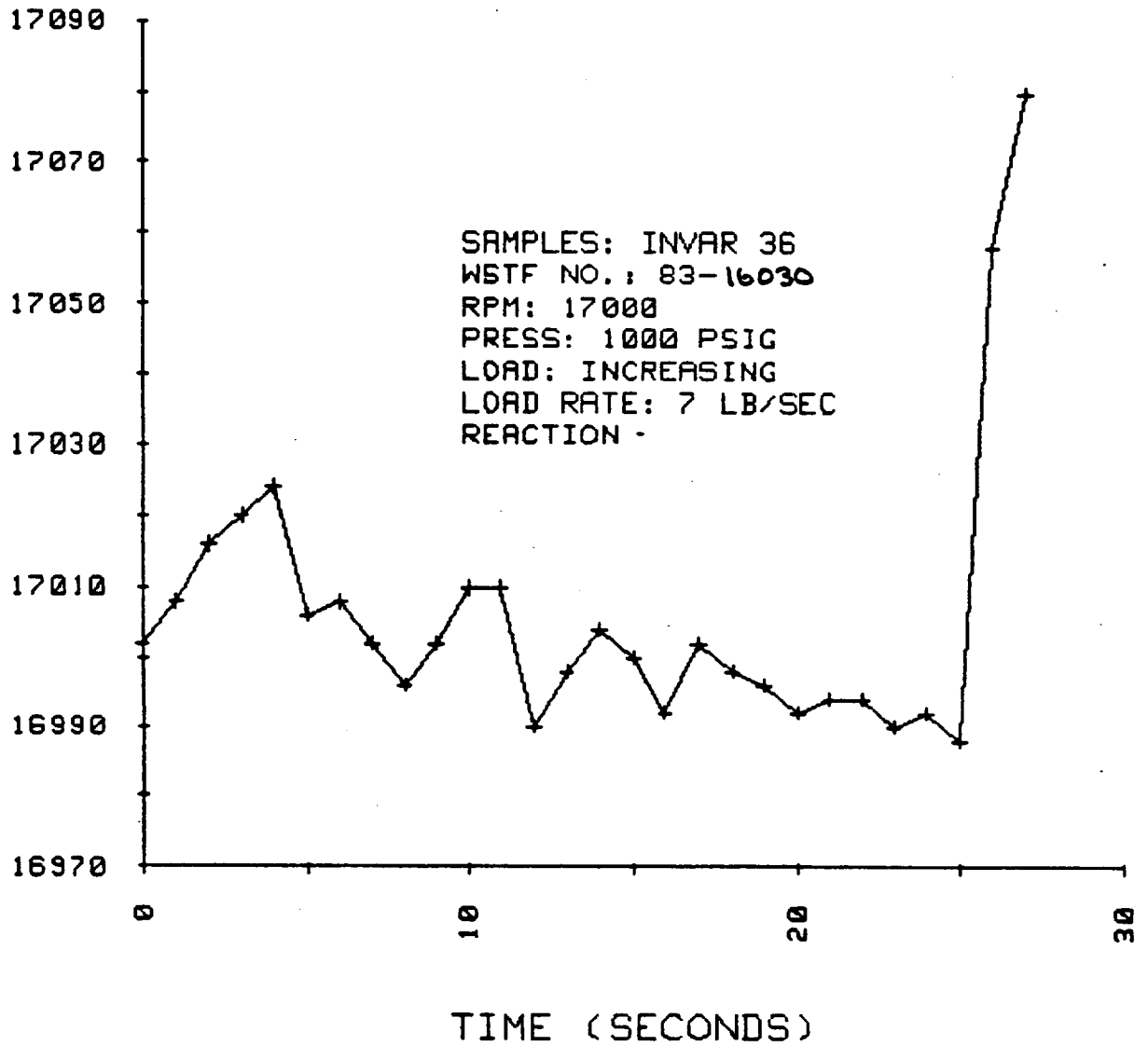
FRT #149 TEST #2 6/16/83

SAMPLES: INVAR 36
WSTF NO.: 83-16030
RPM: 17000
PRESS: 1000 PSIG
LOAD: INCREASING
LOAD RATE: 7 LB/SEC
REACTION



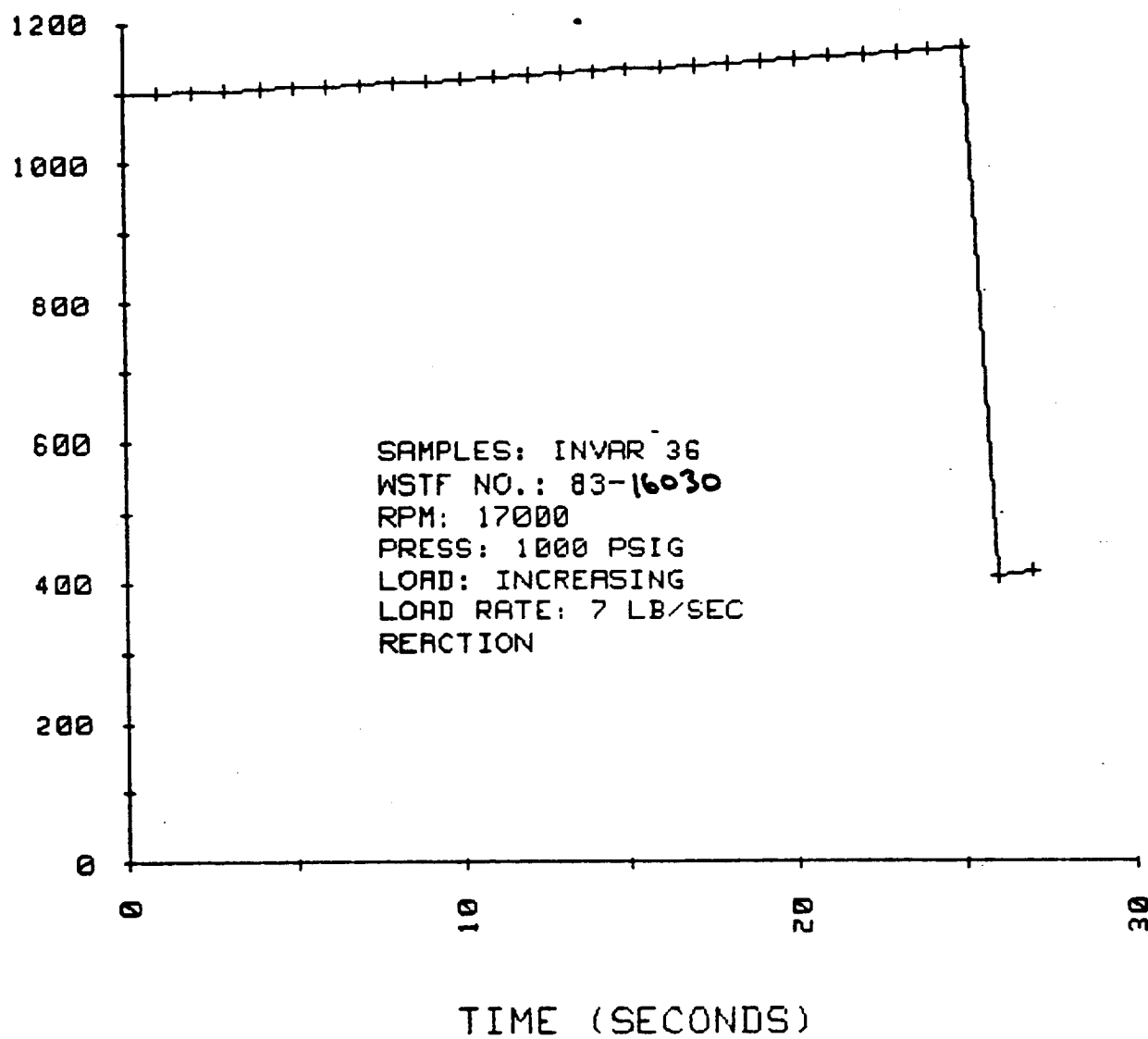
FRT #149 TEST #2 6/16/83

RPM (REVOLUTIONS PER MINUTE)



CHAMBER PRESSURE (PSIG)

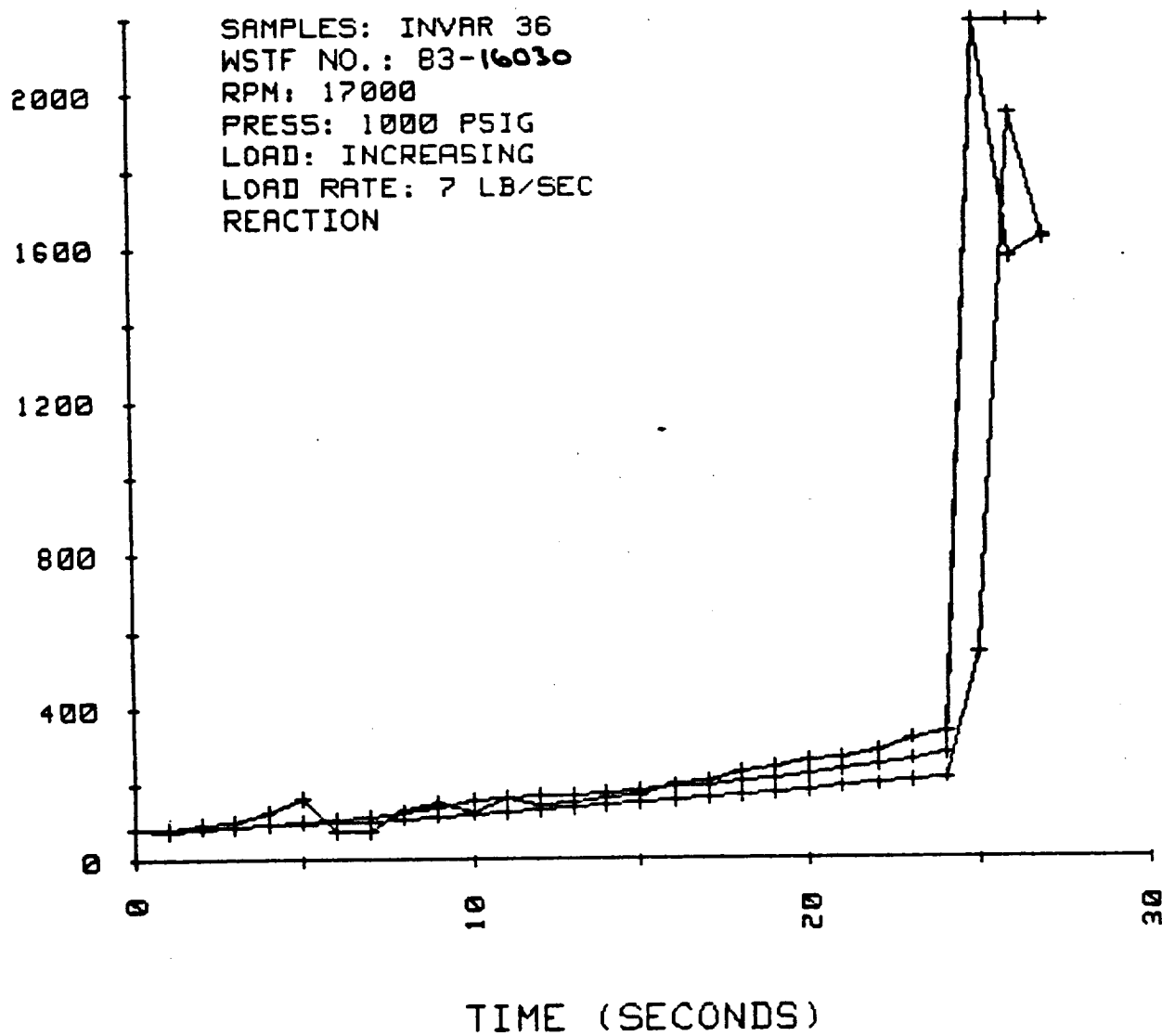
FRT #149 TEST #2 6/16/83



FRT #149 TEST #2 6/16/83

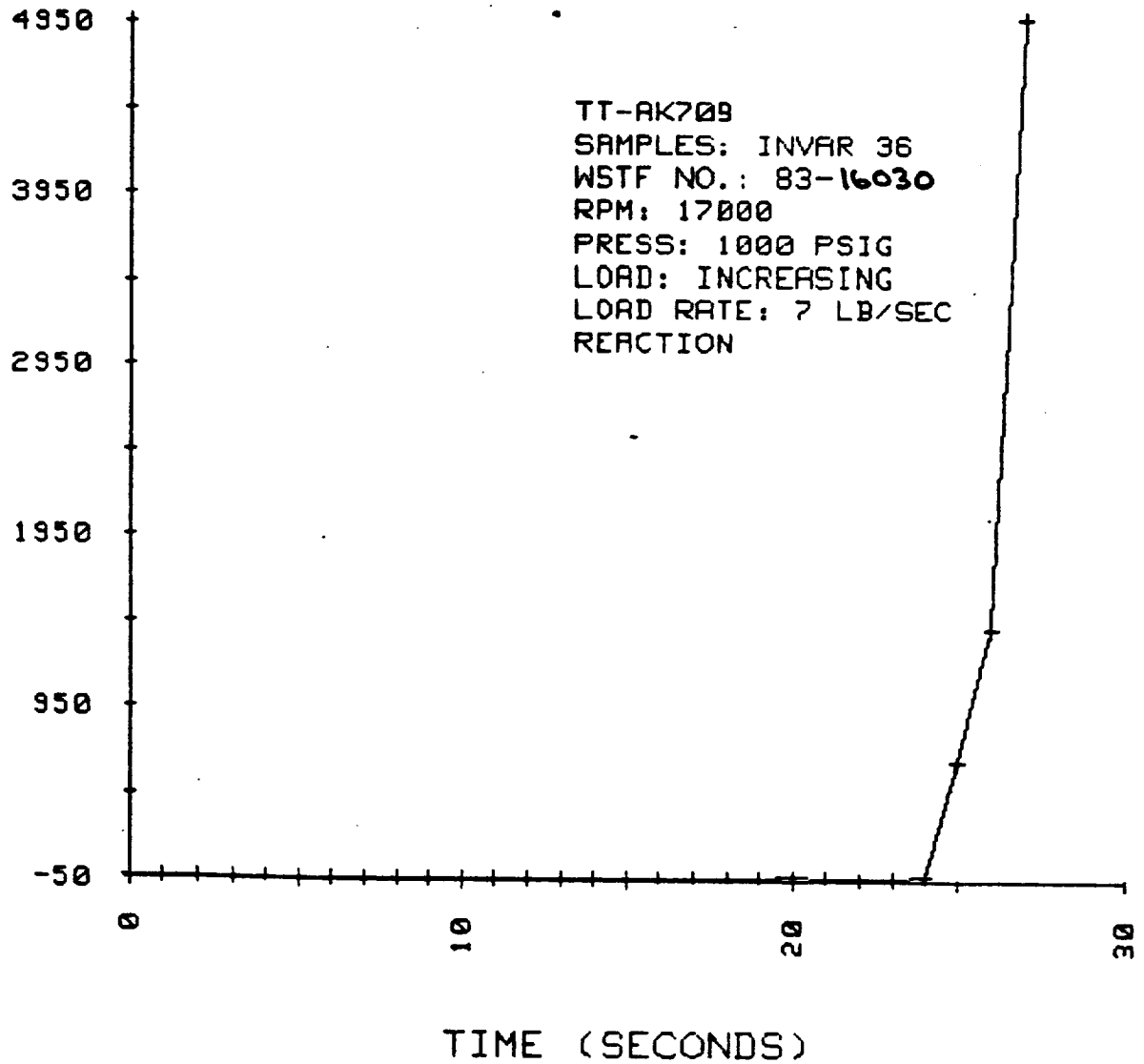
SAMPLES: INVAR 36
WSTF NO.: 83-16030
RPM: 17000
PRESS: 1000 PSIG
LOAD: INCREASING
LOAD RATE: 7 LB/SEC
REACTION

TEMPERATURE (DEG F)



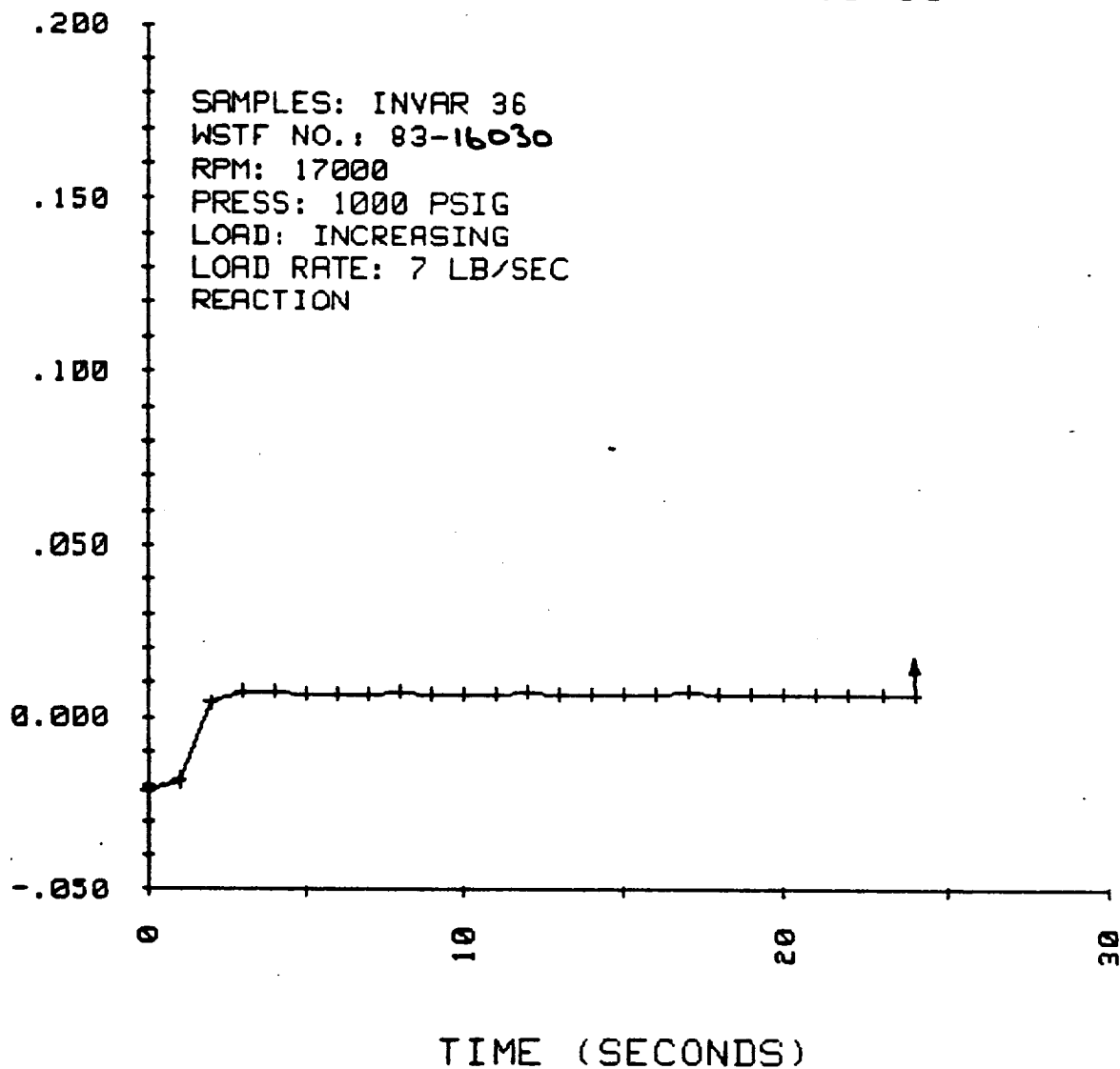
FRT #149 TEST #2 6/16/83

THERMOPILE OUTPUT (1/100MV)

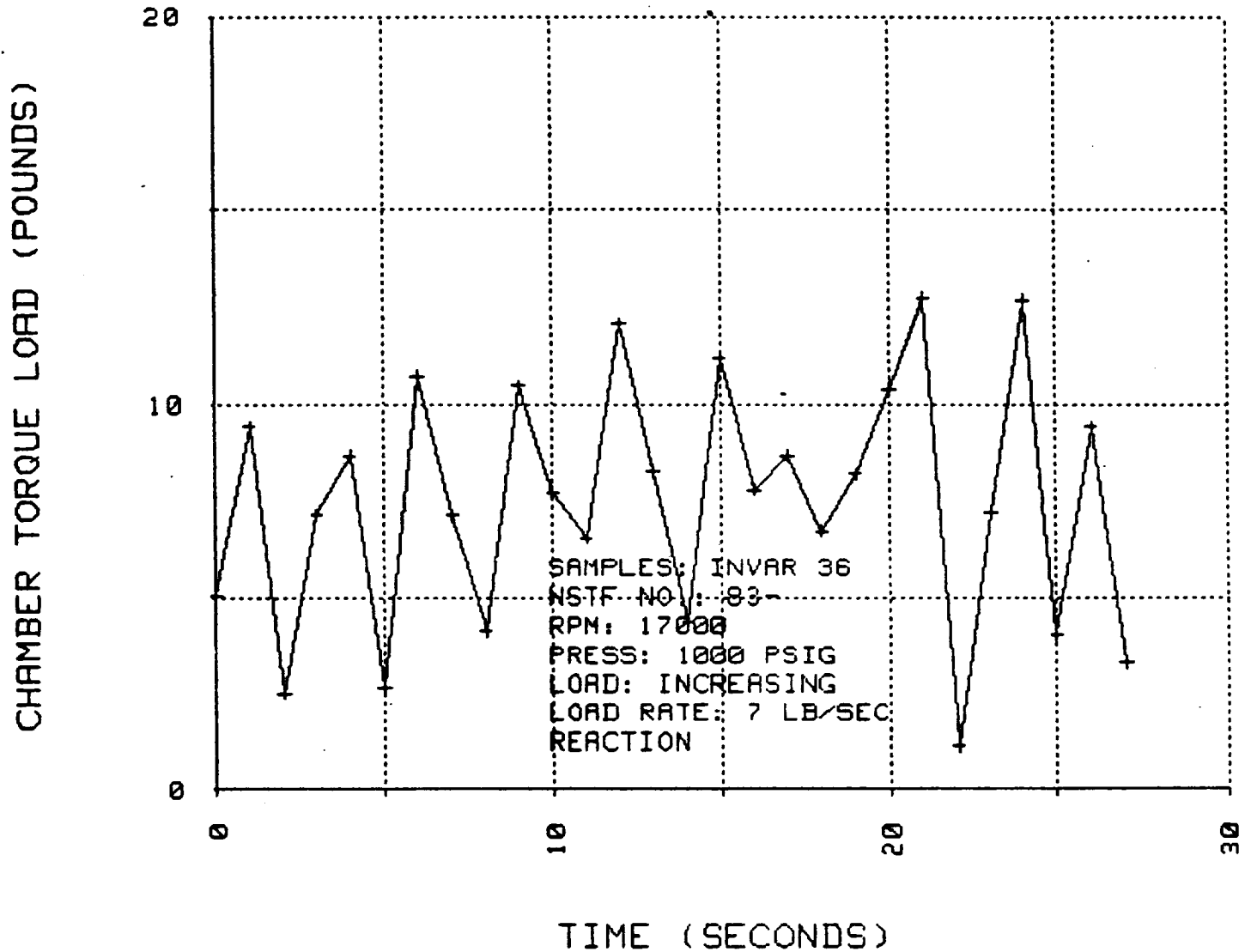


SAMPLE DISPLACEMENT (INCHES)

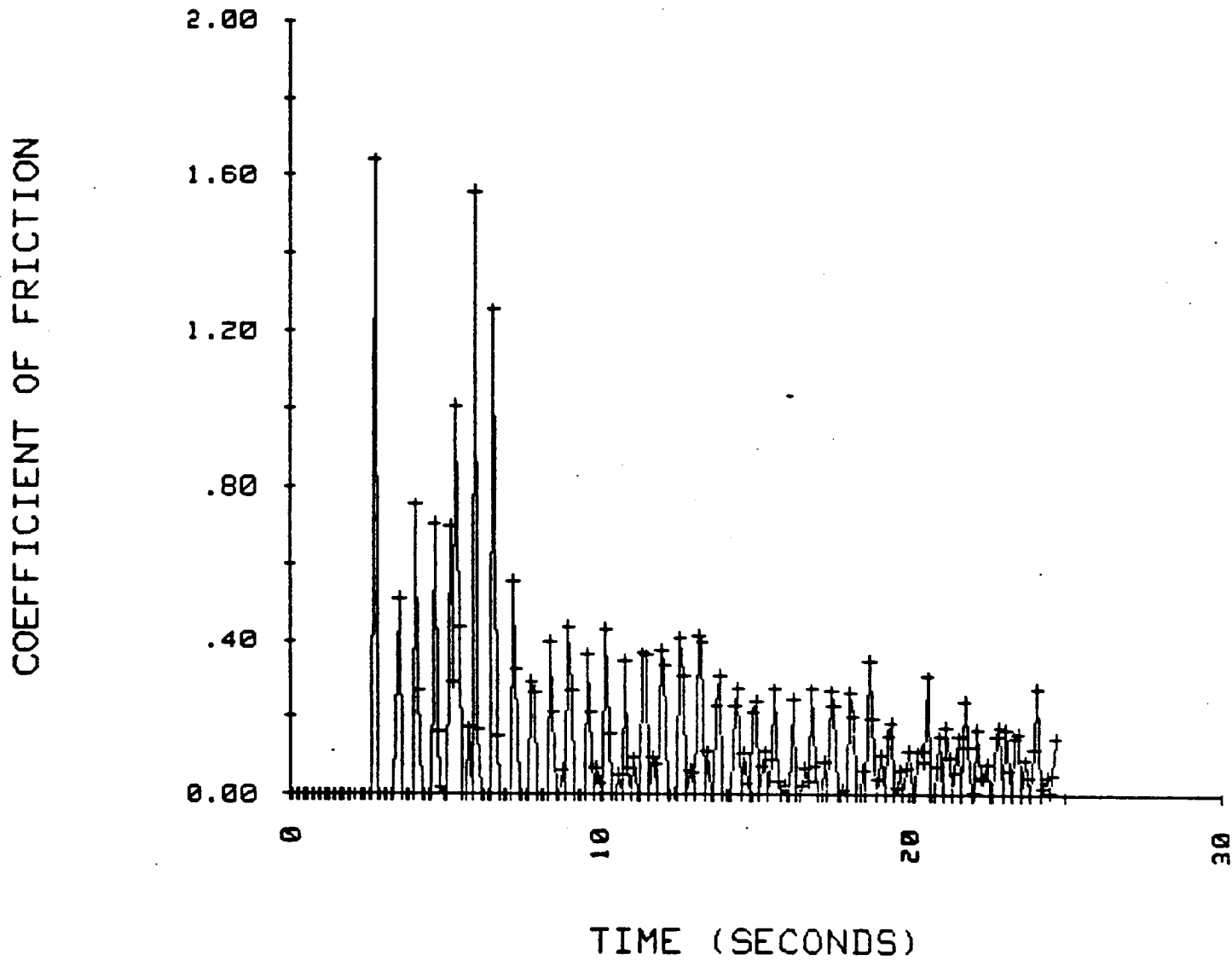
FRT #149 TEST #2 6/16/83



FRT #149 TEST #2 6/16/83

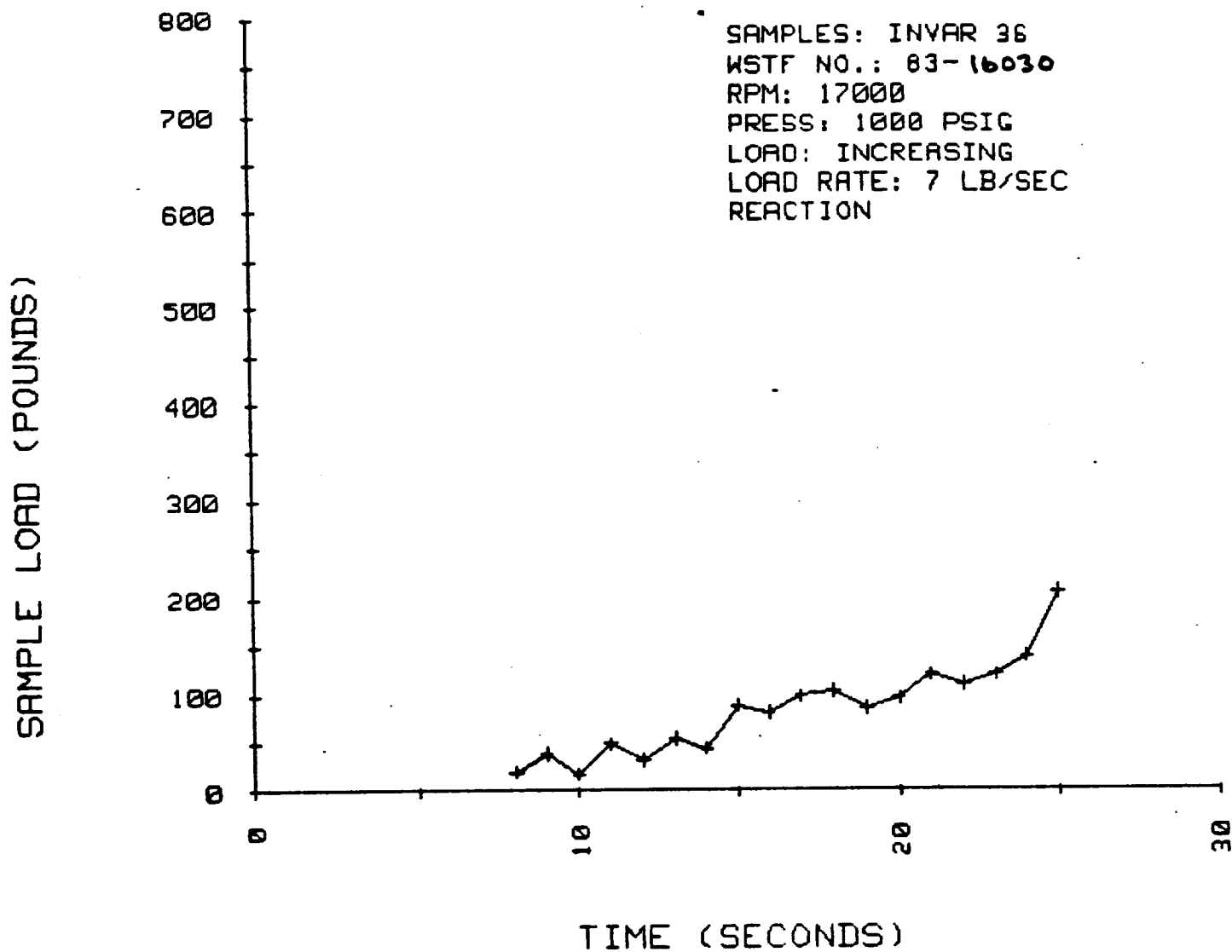


FRT #149 6/17/83



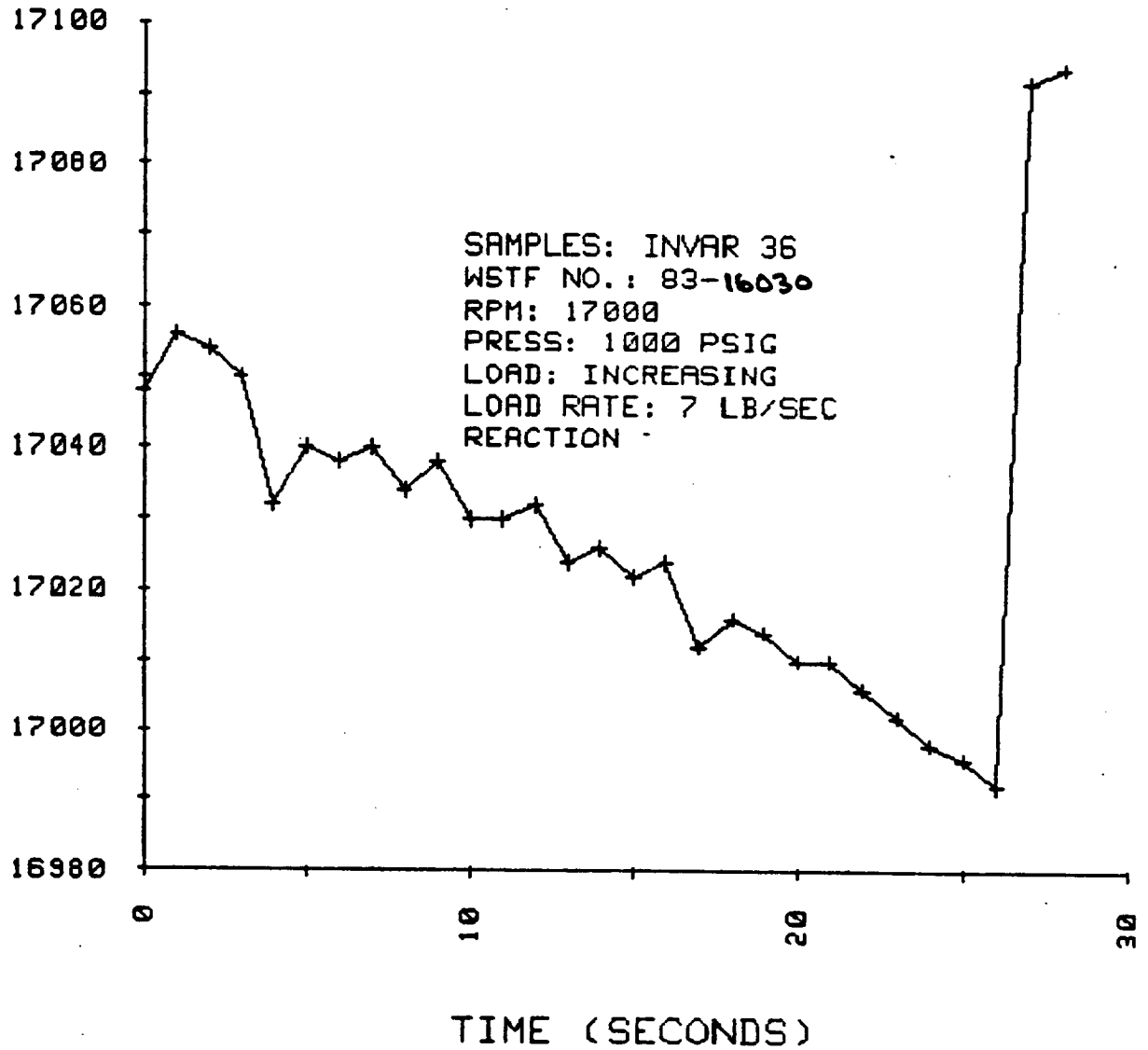
FRT #150 TEST #1 6/17/83

SAMPLES: INVAR 36
WSTF NO.: 83-16030
RPM: 17000
PRESS: 1000 PSIG
LOAD: INCREASING
LOAD RATE: 7 LB/SEC
REACTION

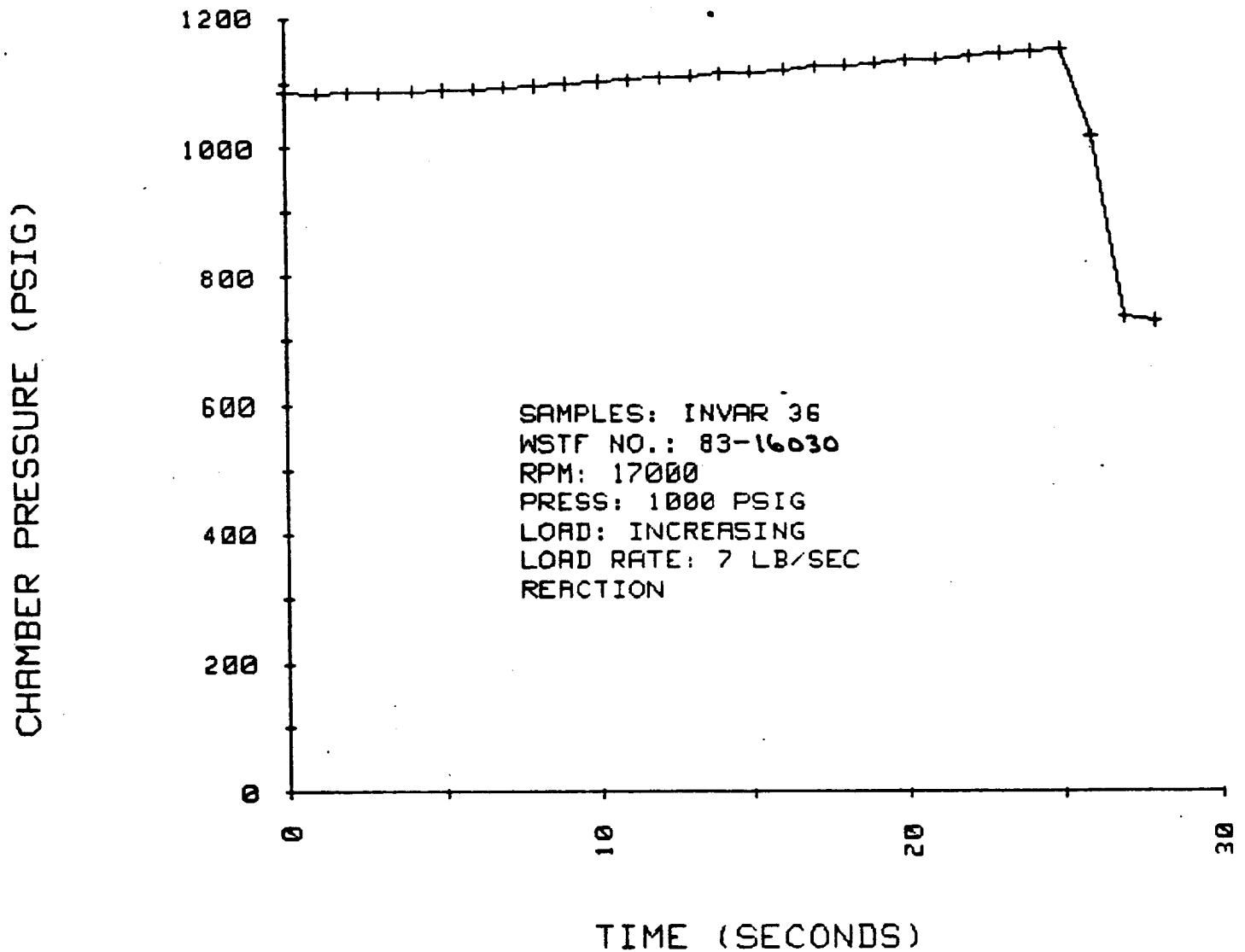


FRT #150 TEST #1 6/17/83

RPM (REVOLUTIONS PER MINUTE)



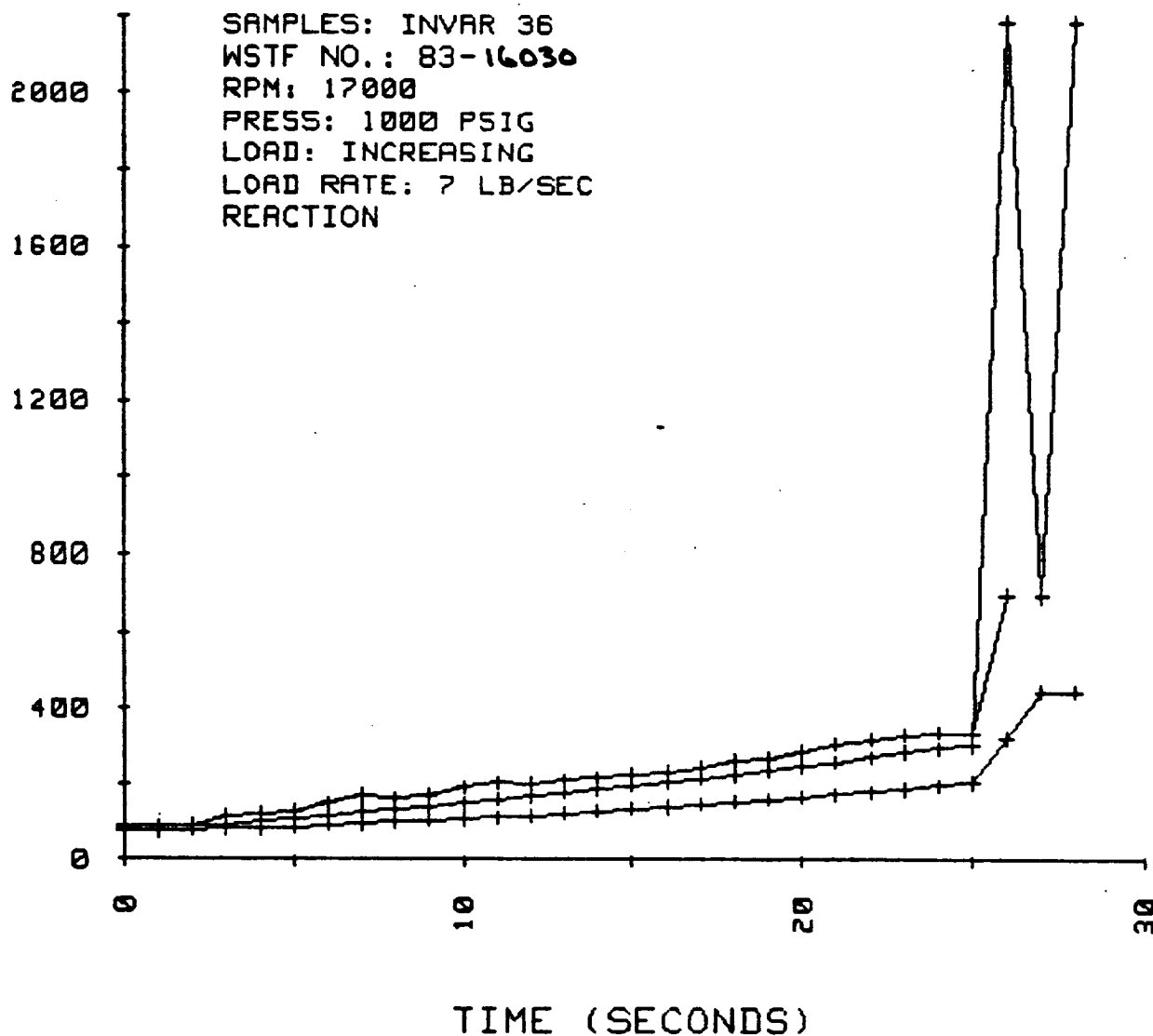
FRT #150 TEST #1 6/17/83



TEMPERATURE (DEG F)

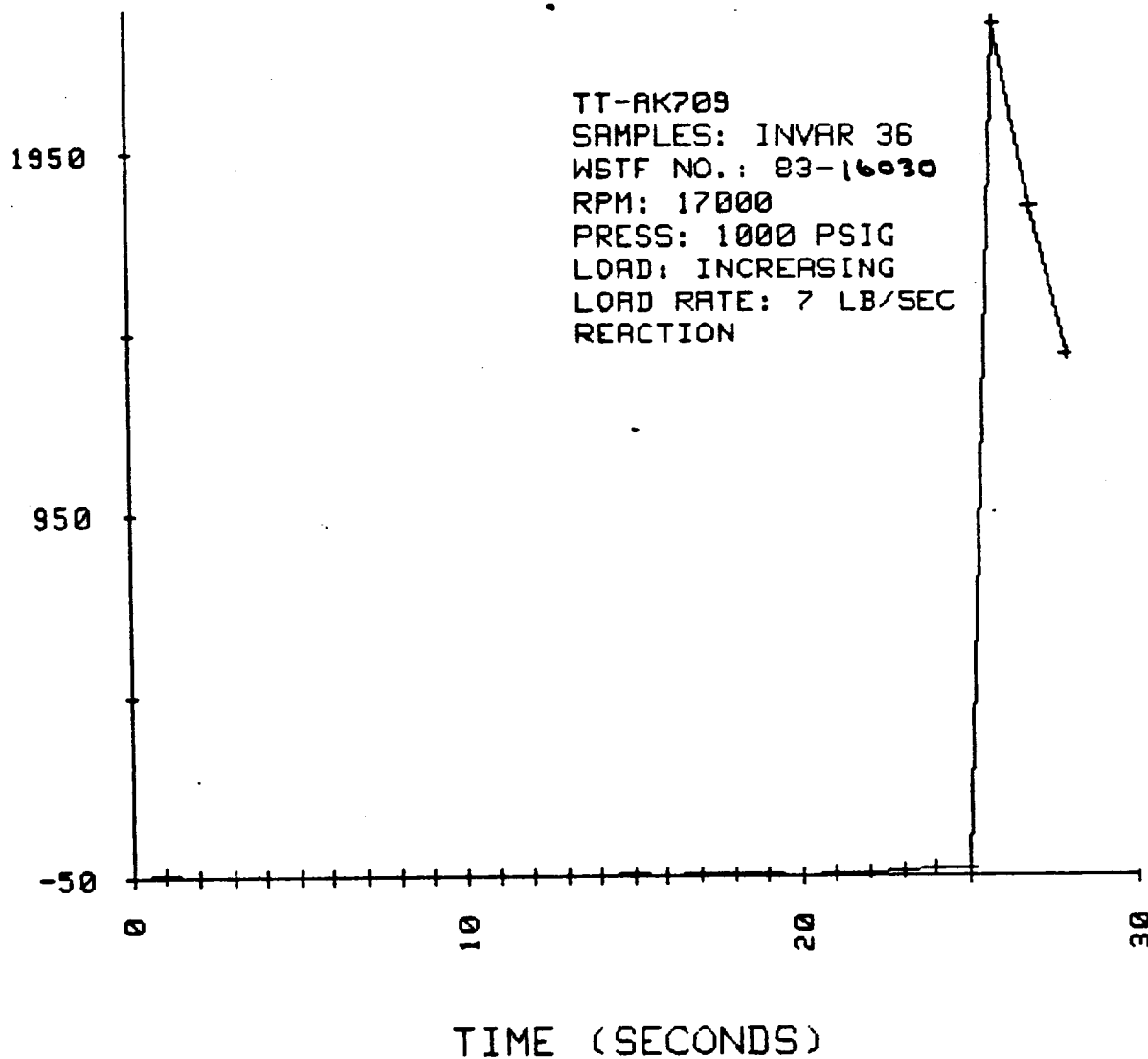
FRT #150 TEST #1 6/17/83

SAMPLES: INVAR 36
WSTF NO.: 83-16030
RPM: 17000
PRESS: 1000 PSIG
LOAD: INCREASING
LOAD RATE: 7 LB/SEC
REACTION



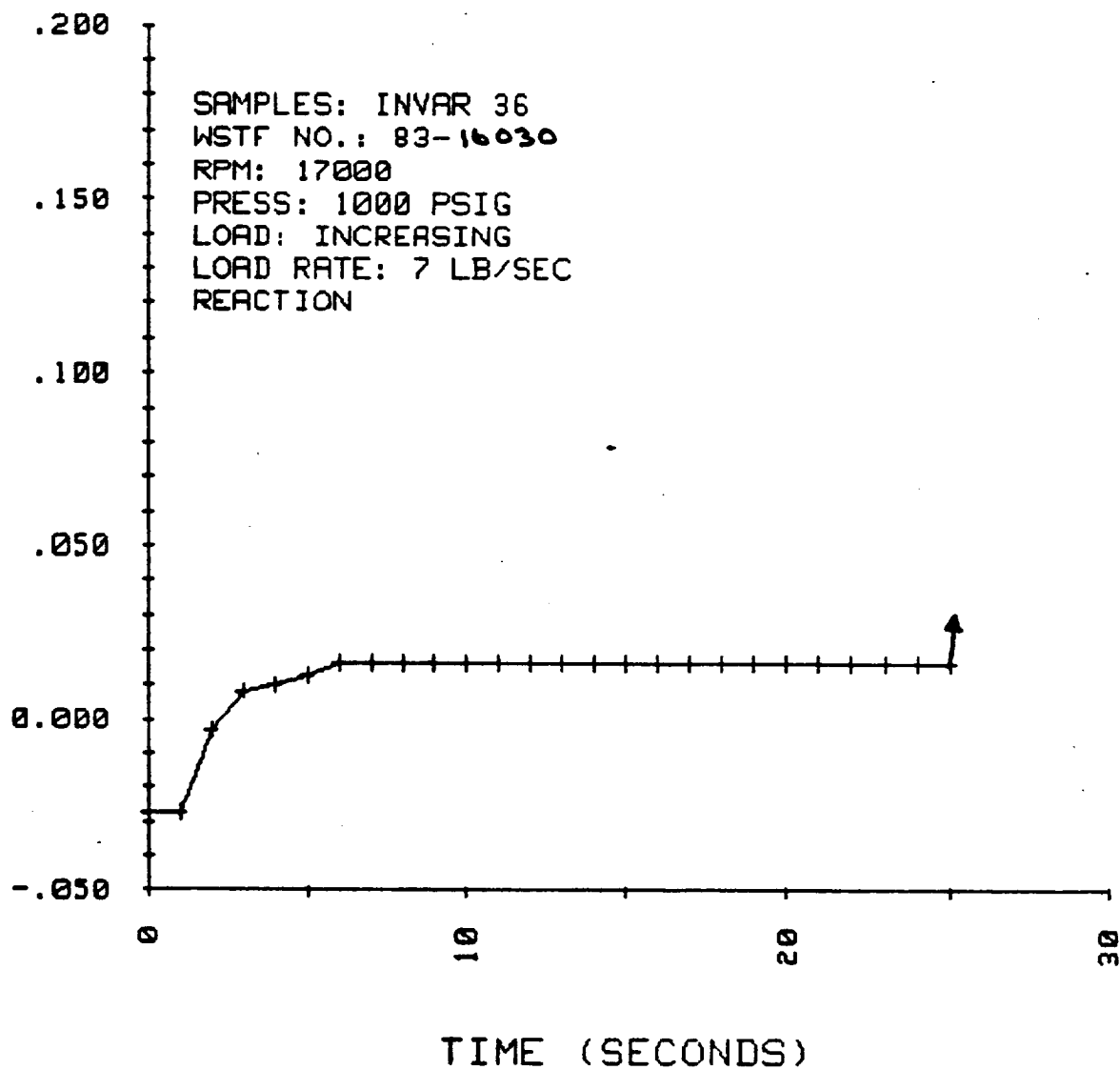
FRT #150 TEST #1 6/17/83

THERMOPILE OUTPUT (1/100MV)

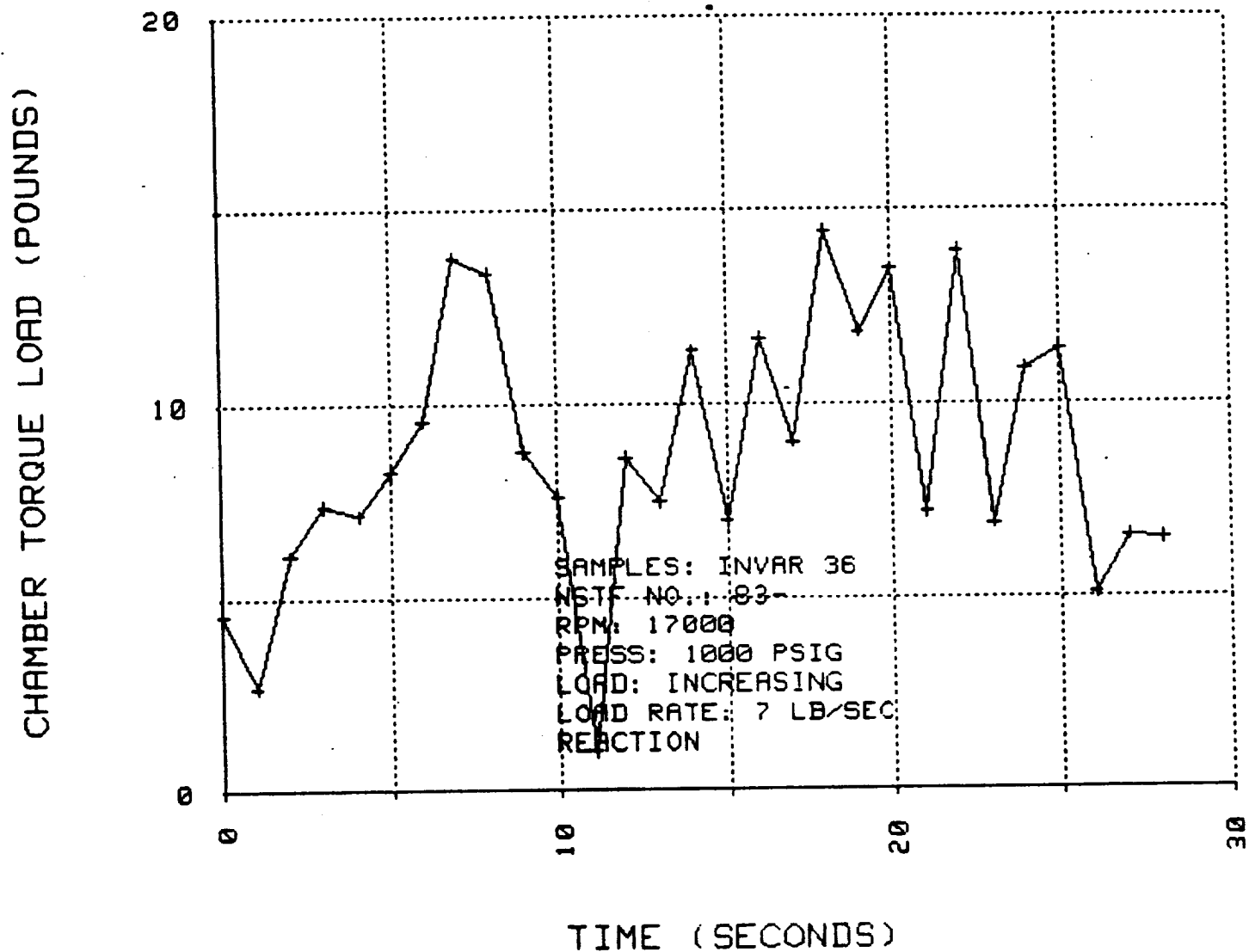


SAMPLE DISPLACEMENT (INCHES)

FRT #150 TEST #1 6/17/83

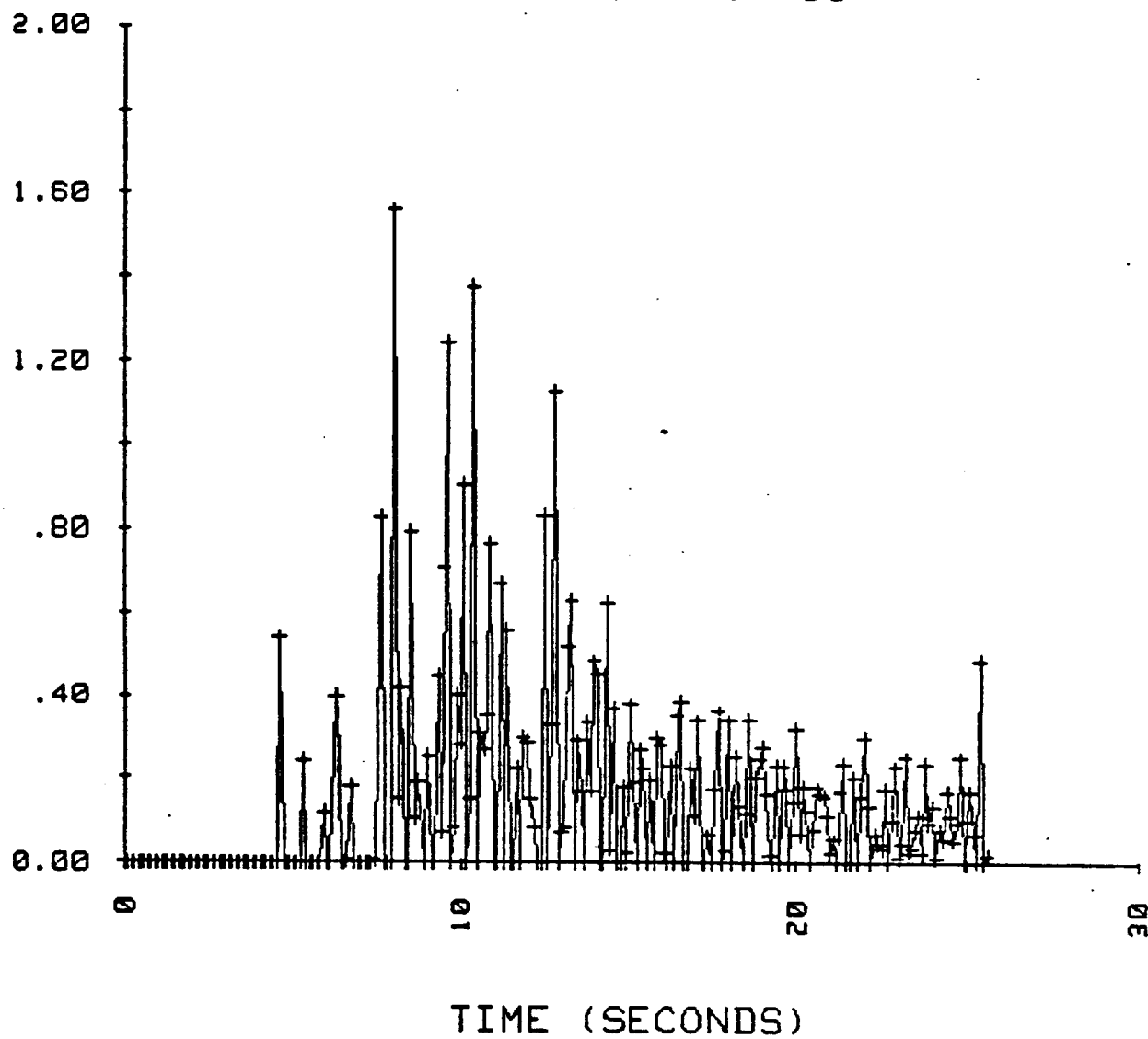


FRT #150 TEST #1 6/17/83



COEFFICIENT OF FRICTION

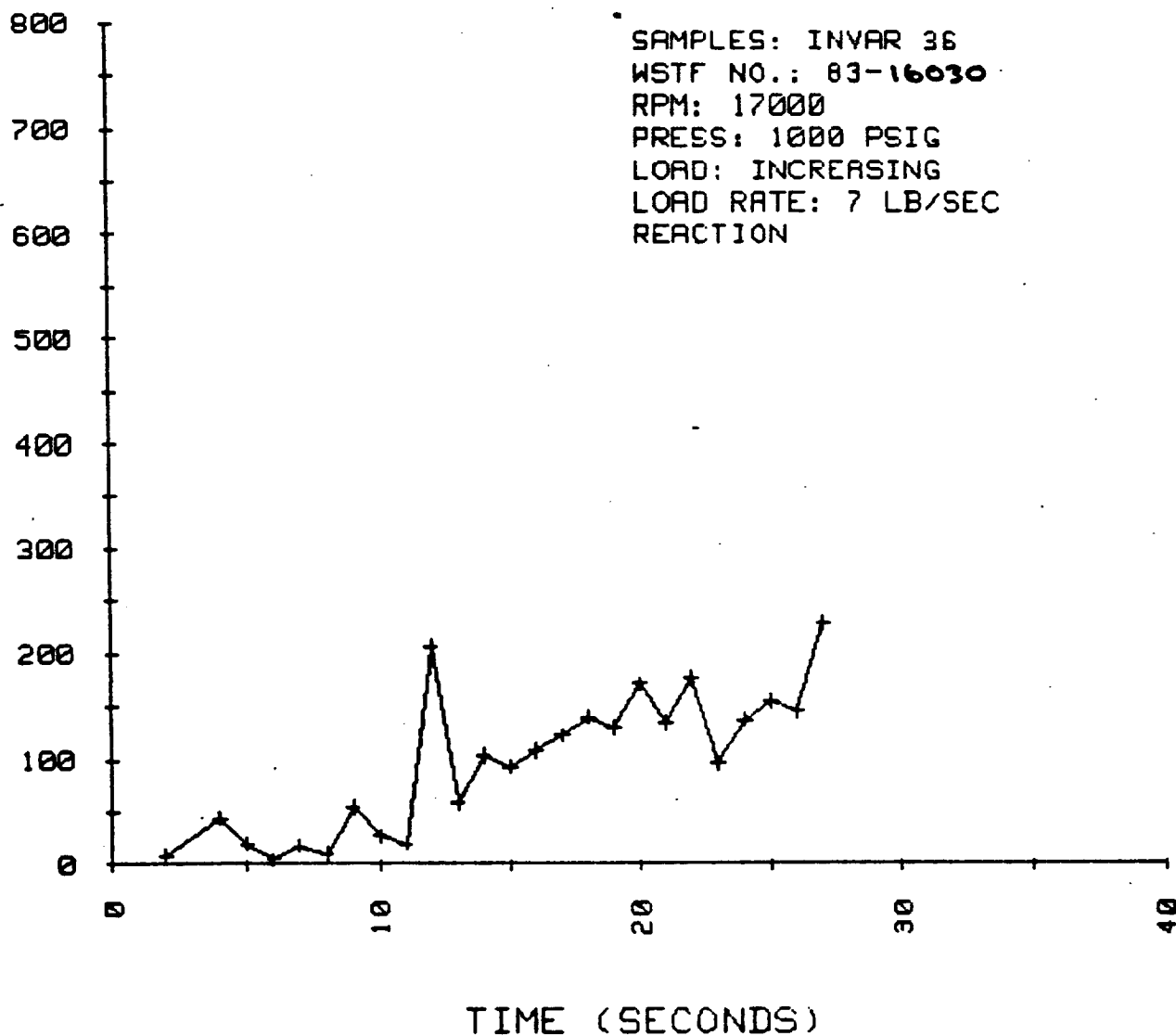
FRT #150 6/17/83



FRT #154 TEST #1 6/21/83

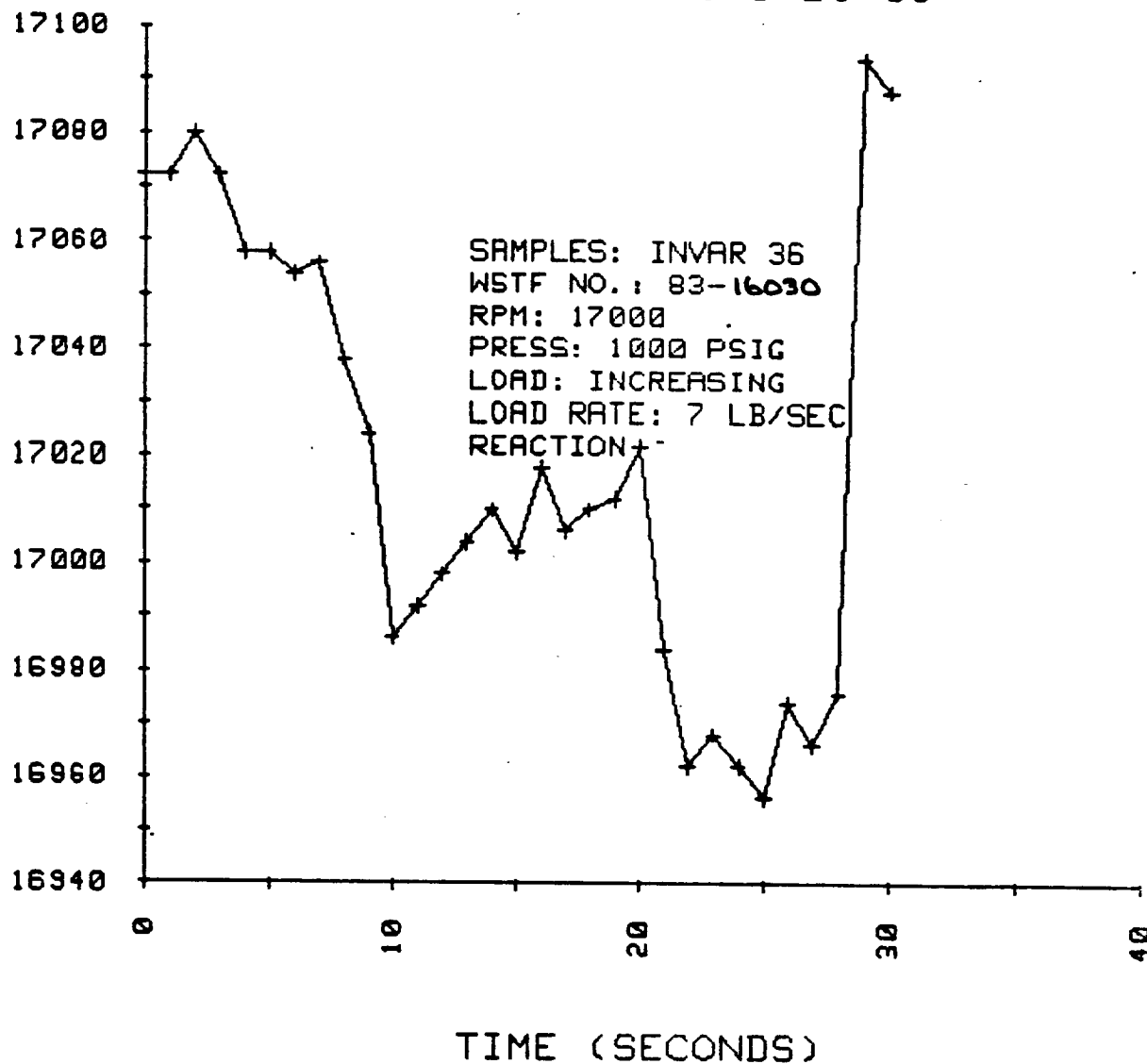
SAMPLES: INVAR 36
WSTF NO.: 83-16030
RPM: 17000
PRESS: 1000 PSIG
LOAD: INCREASING
LOAD RATE: 7 LB/SEC
REACTION

SAMPLE LOAD (POUNDS)



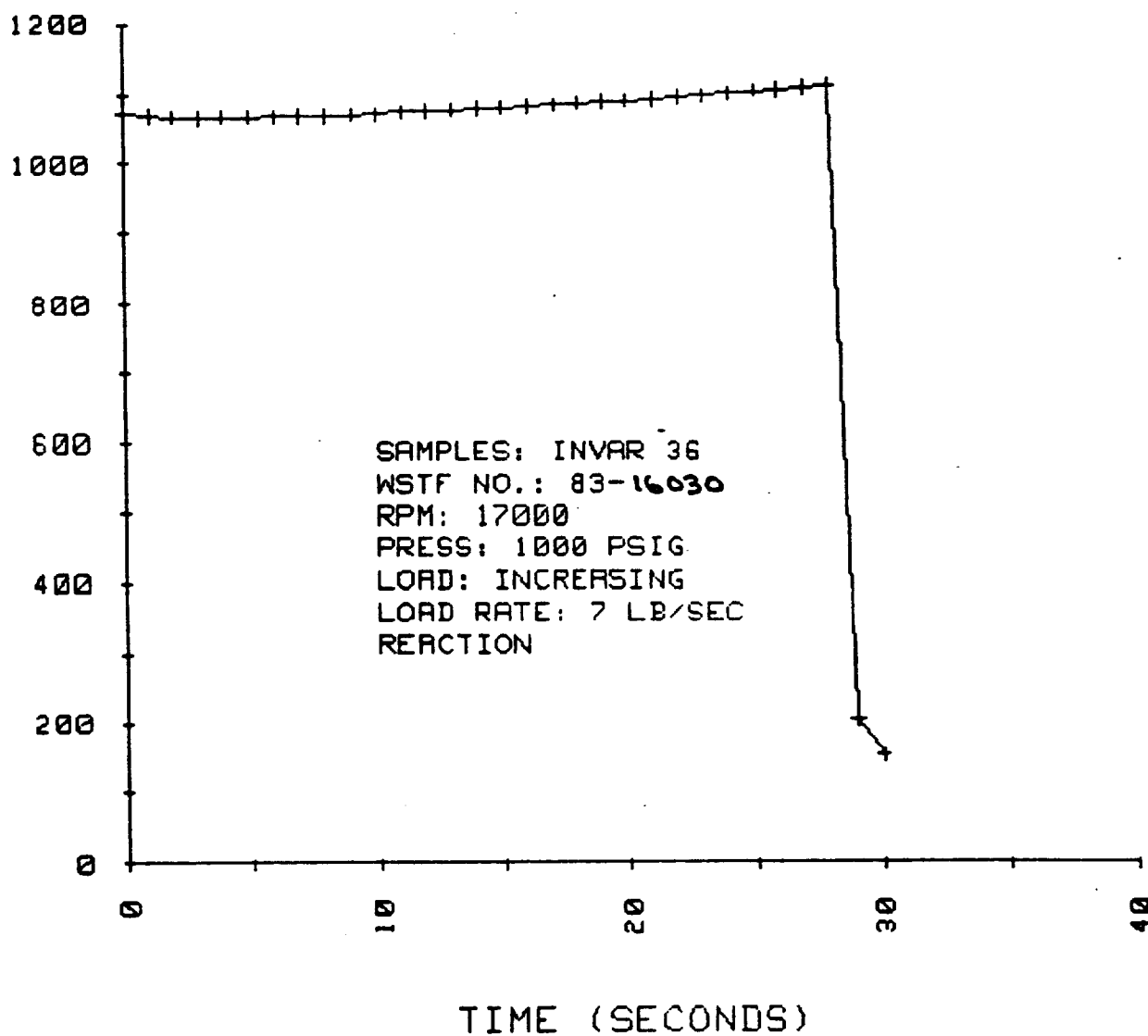
FRT #154 TEST #1 6/21/83

RPM (REVOLUTIONS PER MINUTE)



FRT #154 TEST #1 6/21/83

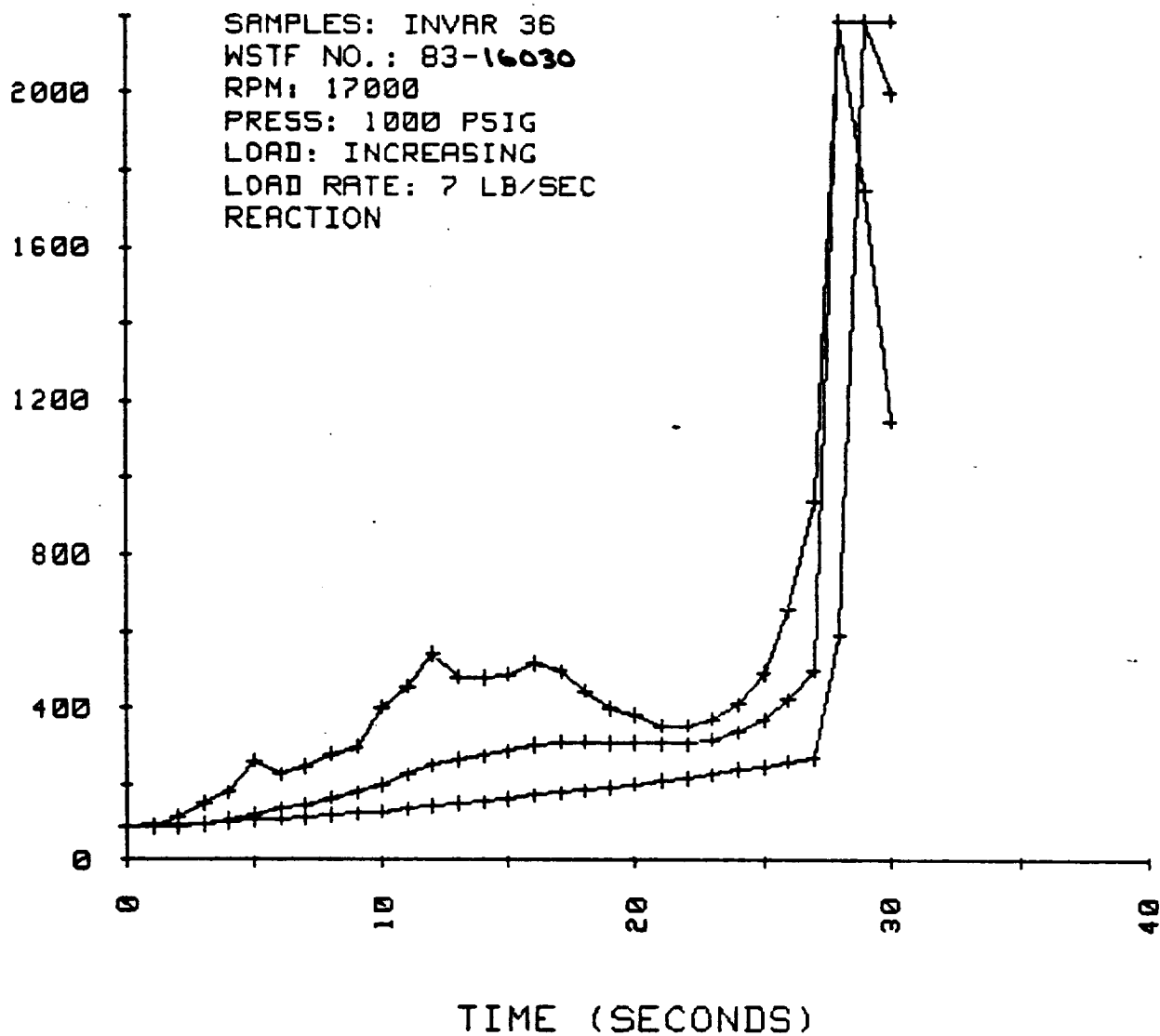
CHAMBER PRESSURE (PSIG)



FRT #154 TEST #1 6/21/83

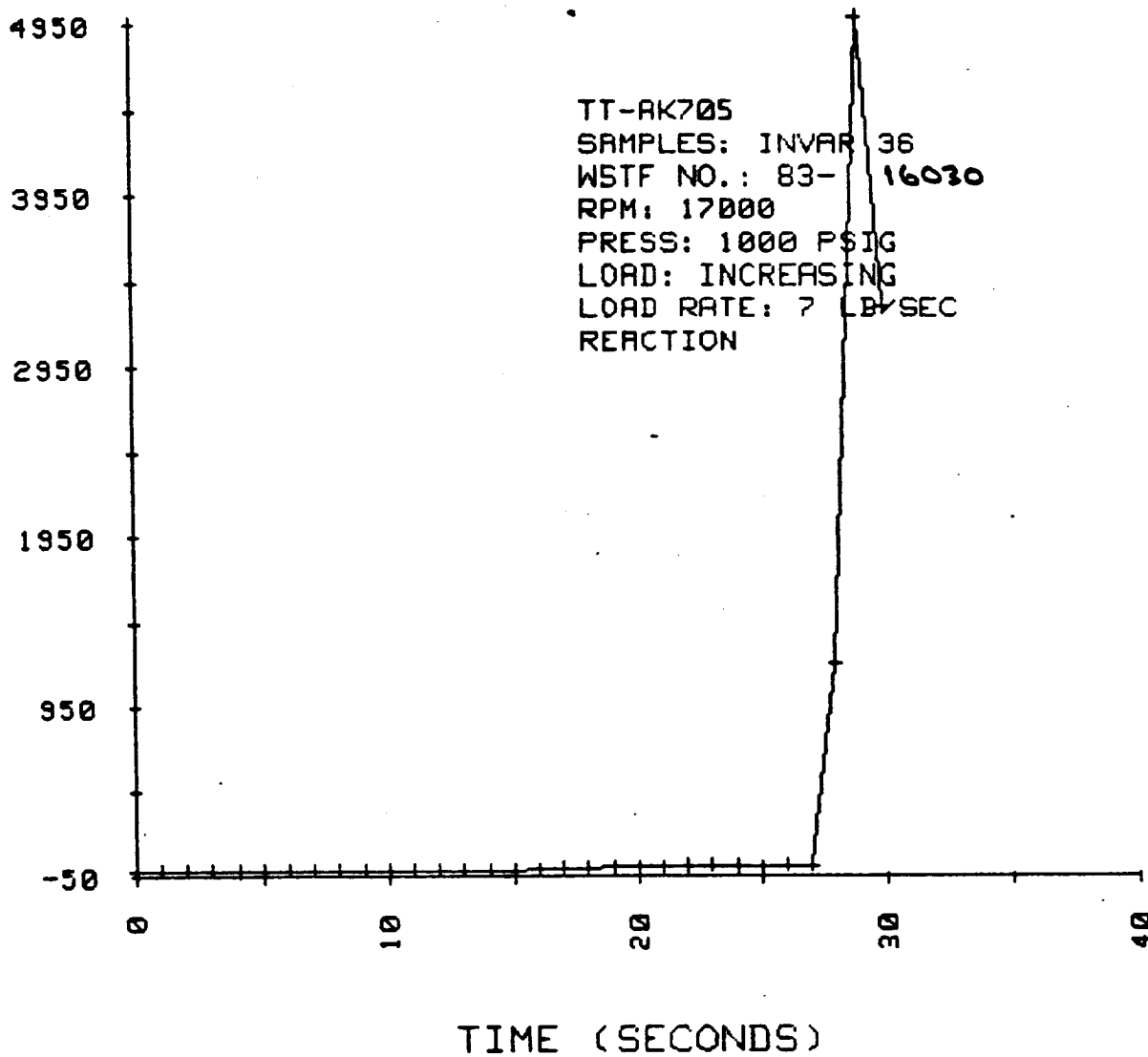
SAMPLES: INVAR 36
WSTF NO.: 83-16030
RPM: 17000
PRESS: 1000 PSIG
LOAD: INCREASING
LOAD RATE: 7 LB/SEC
REACTION

TEMPERATURE (DEG F)



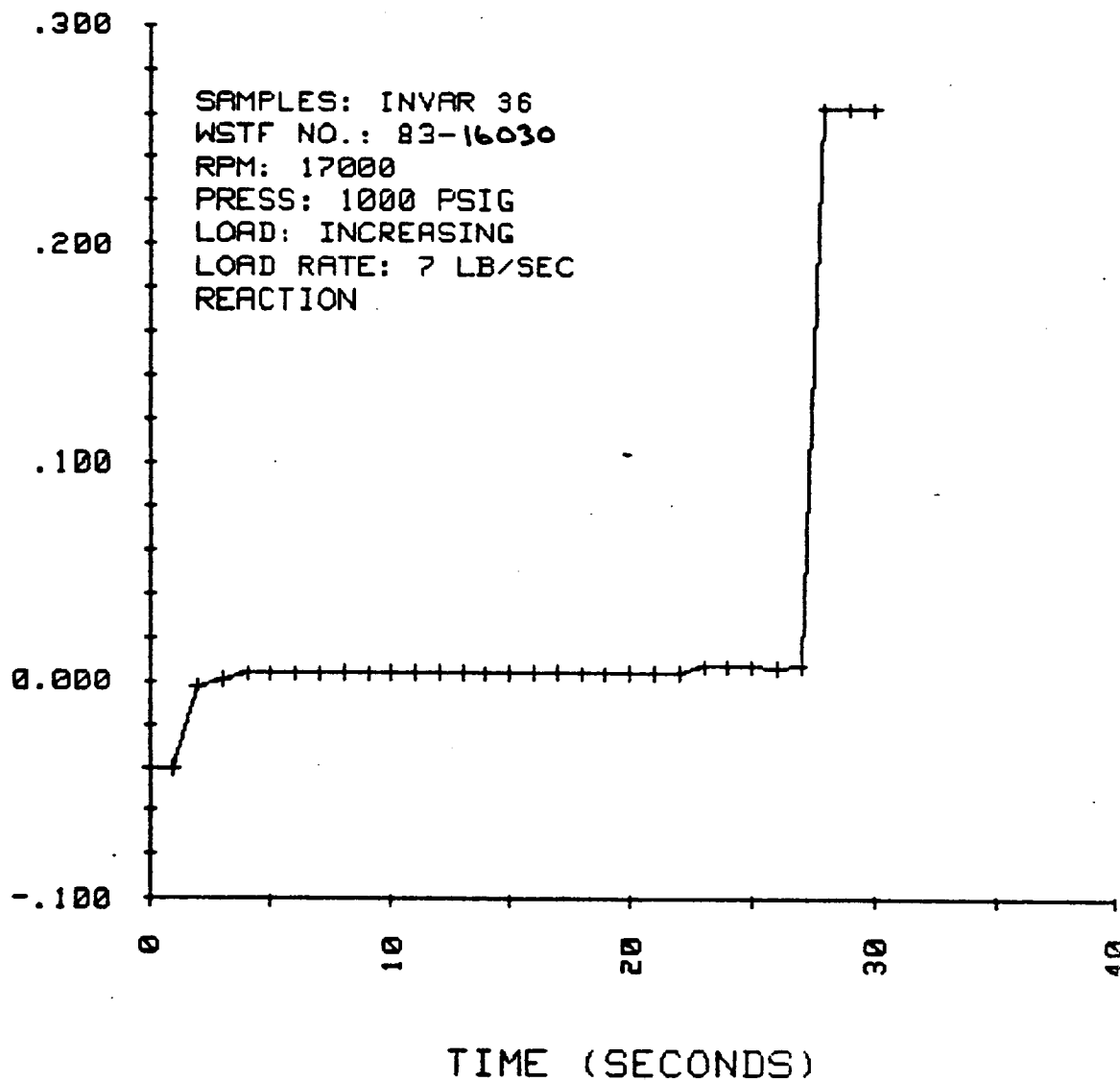
FRT #154 TEST #1 6/21/83

THERMOPILE OUTPUT (1/100MV)



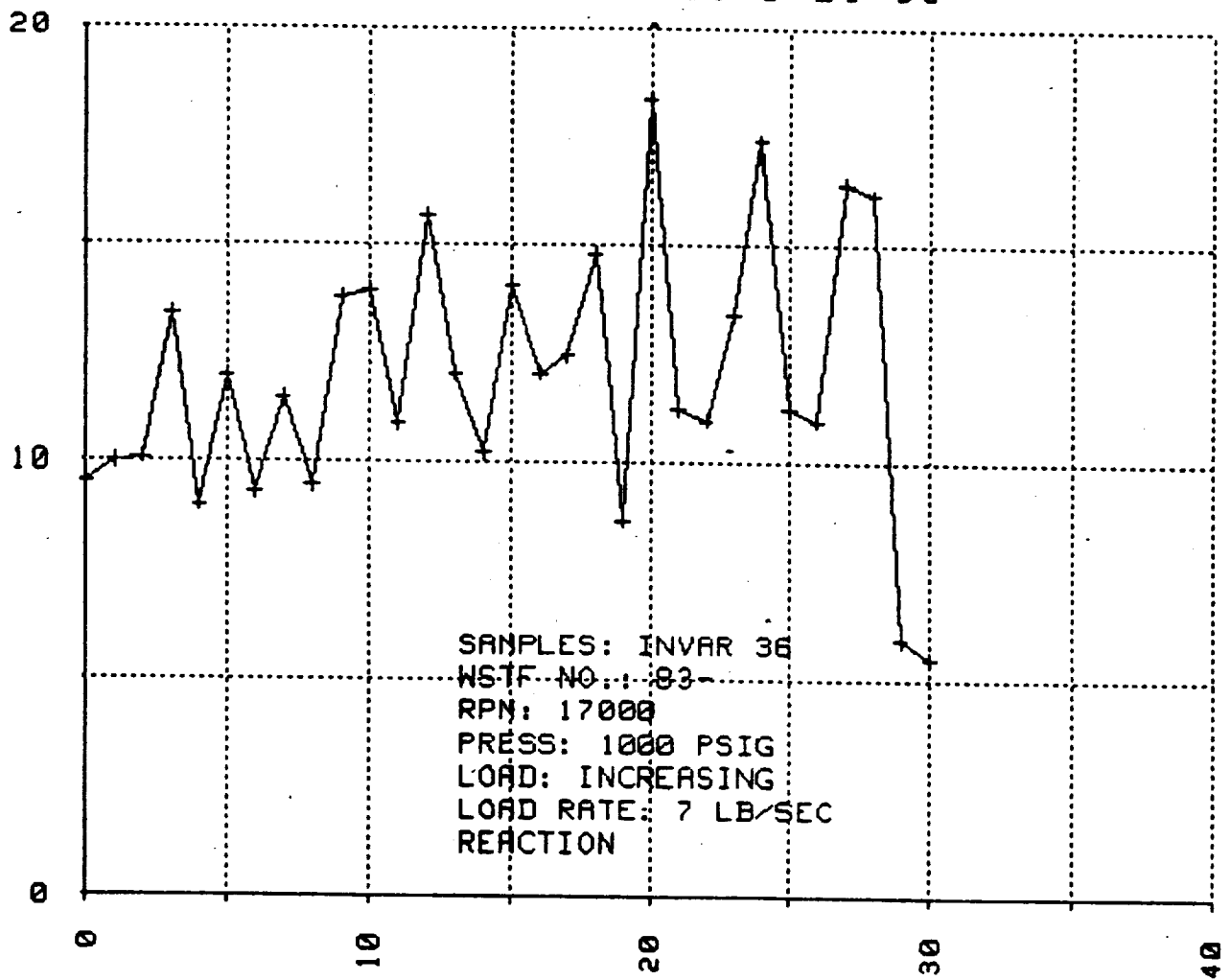
SAMPLE DISPLACEMENT (INCHES)

FRT #154 TEST #1 6/21/83



FRT #154 TEST #1 6/21/83

CHAMBER TORQUE LOAD (POUNDS)

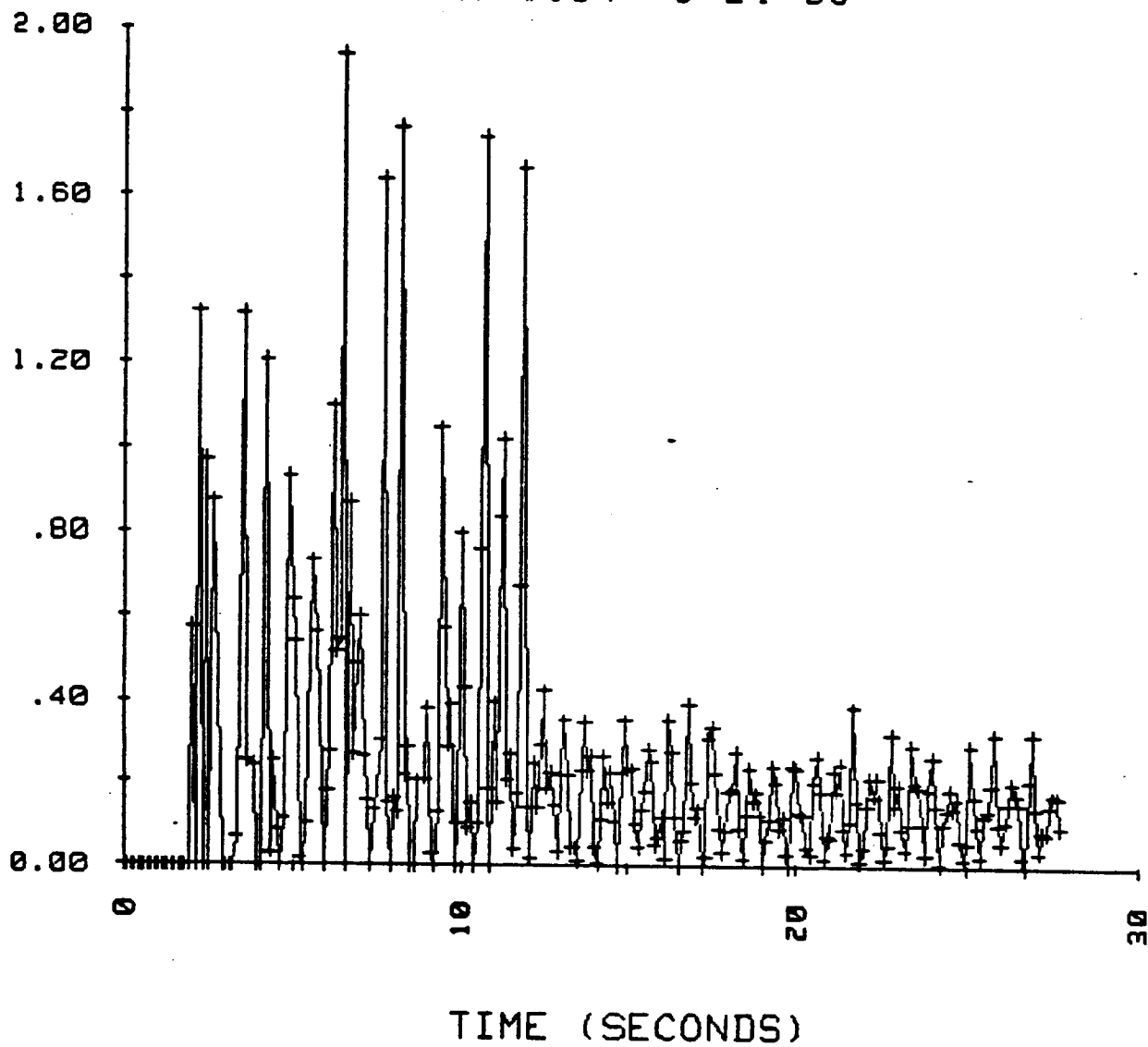


SAMPLES: INVAR 36
WSTF NO.: 83-
RPN: 17000
PRESS: 1000 PSIG
LOAD: INCREASING
LOAD RATE: 7 LB/SEC
REACTION

TIME (SECONDS)

COEFFICIENT OF FRICTION

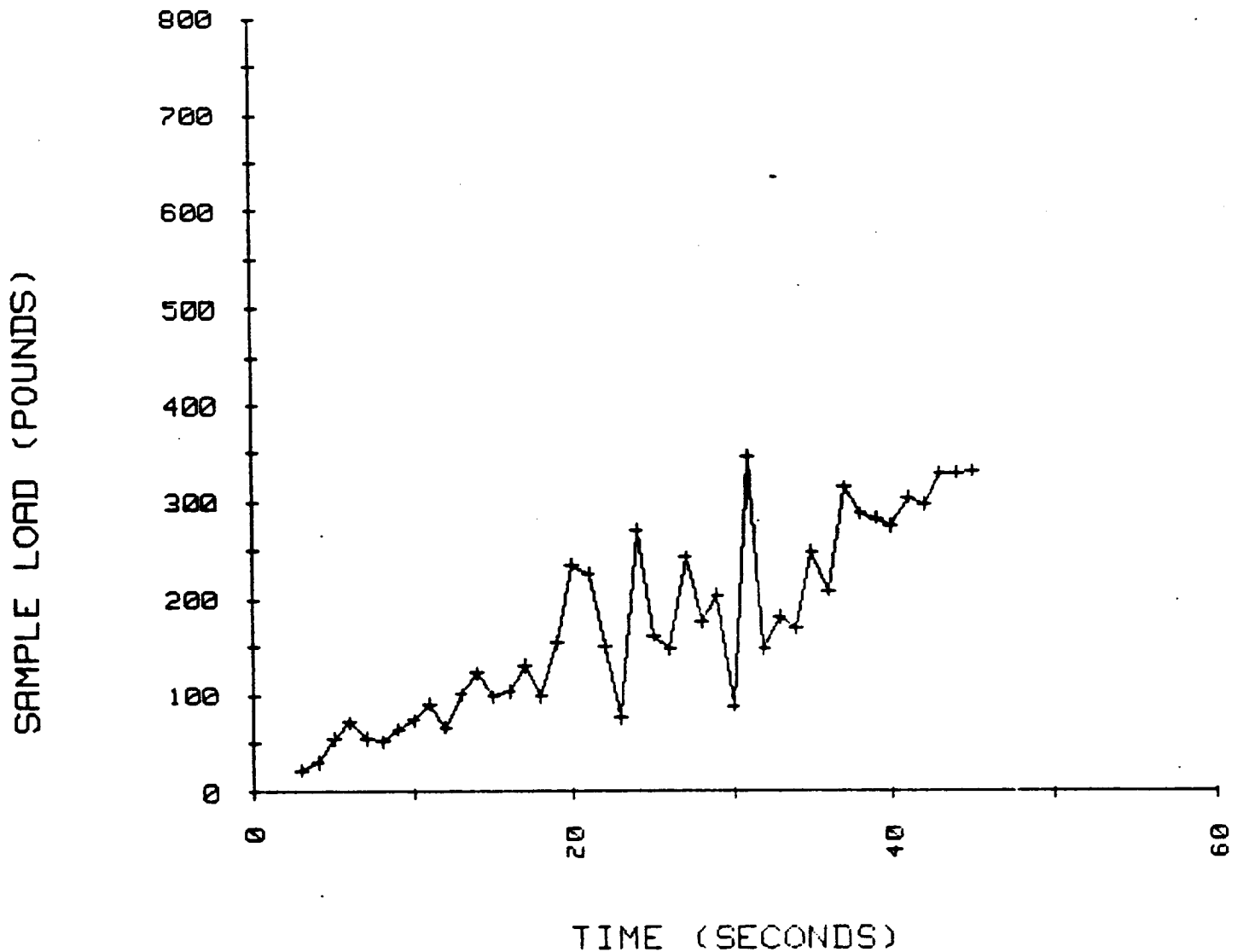
FRT #154 6/21/83



FRT #179

SAMPLES: MONEL K-500
TEST RESULTS: REACTION

SPEED: 17000 RPM (67 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (25 PSI/SEC)

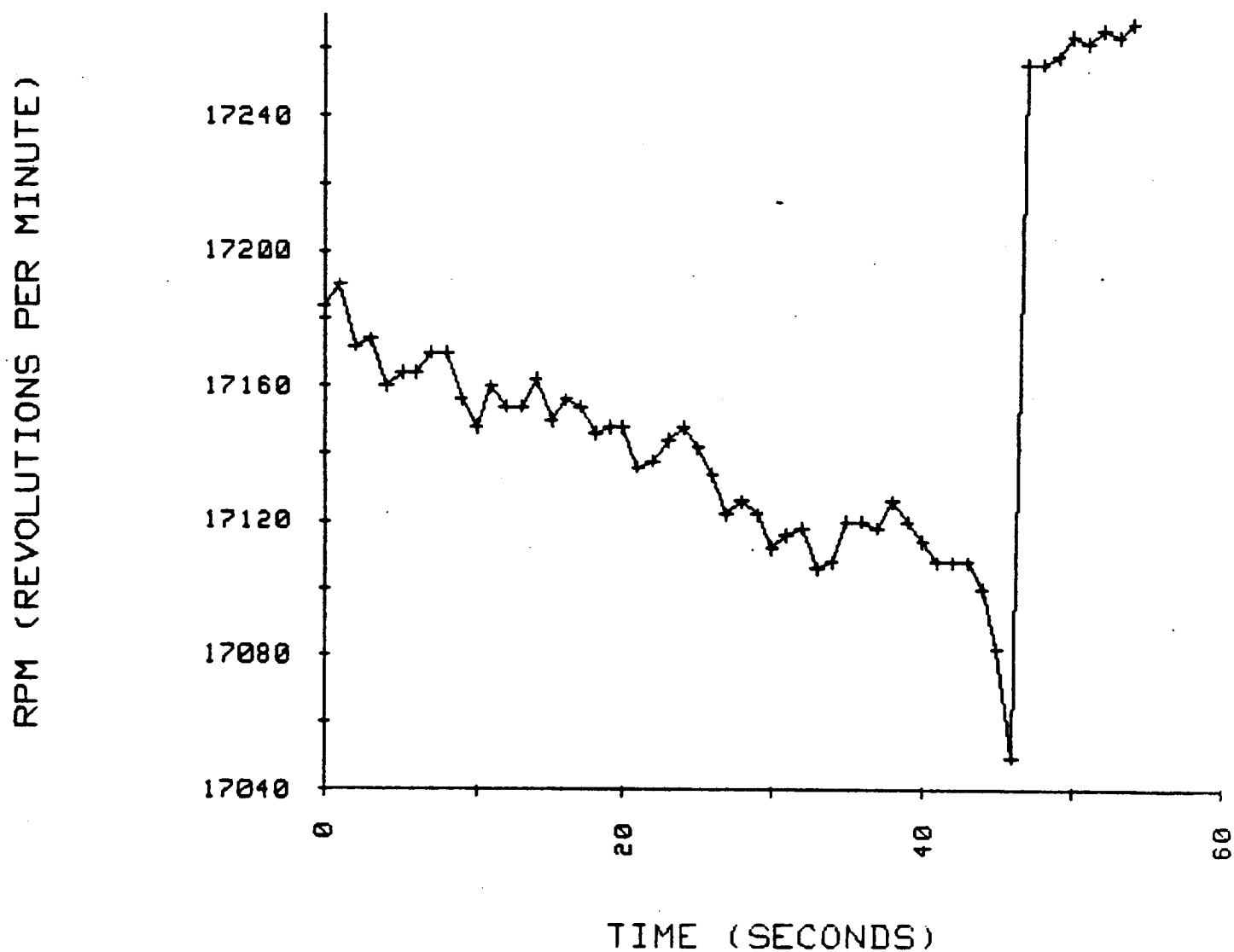


D-70

FRT #179

SAMPLES: MONEL K-500
TEST RESULTS: REACTION

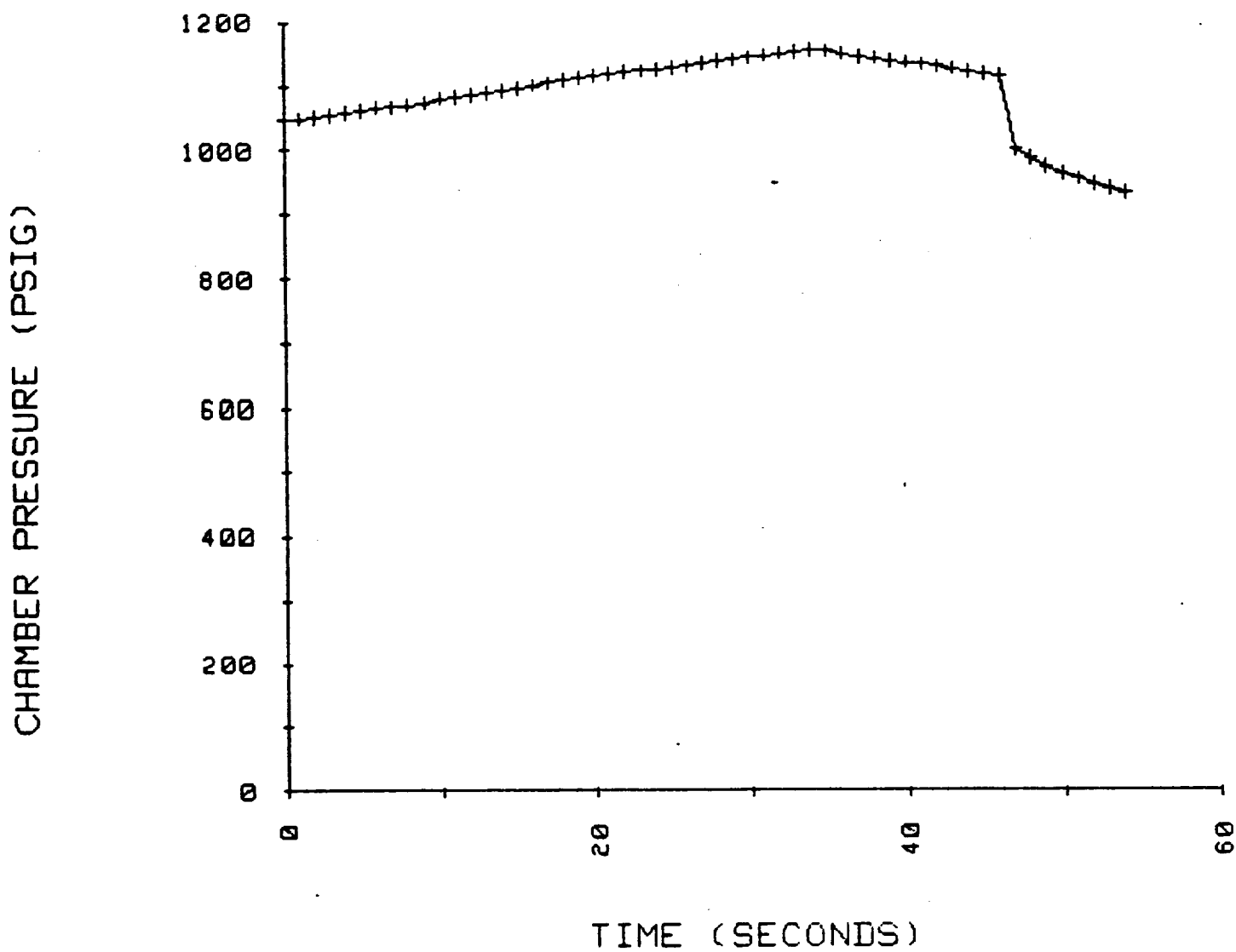
SPEED: 17000 RPM (67 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (25 PSI/SEC)



FRT #179

SAMPLES: MONEL K-500
TEST RESULTS: REACTION

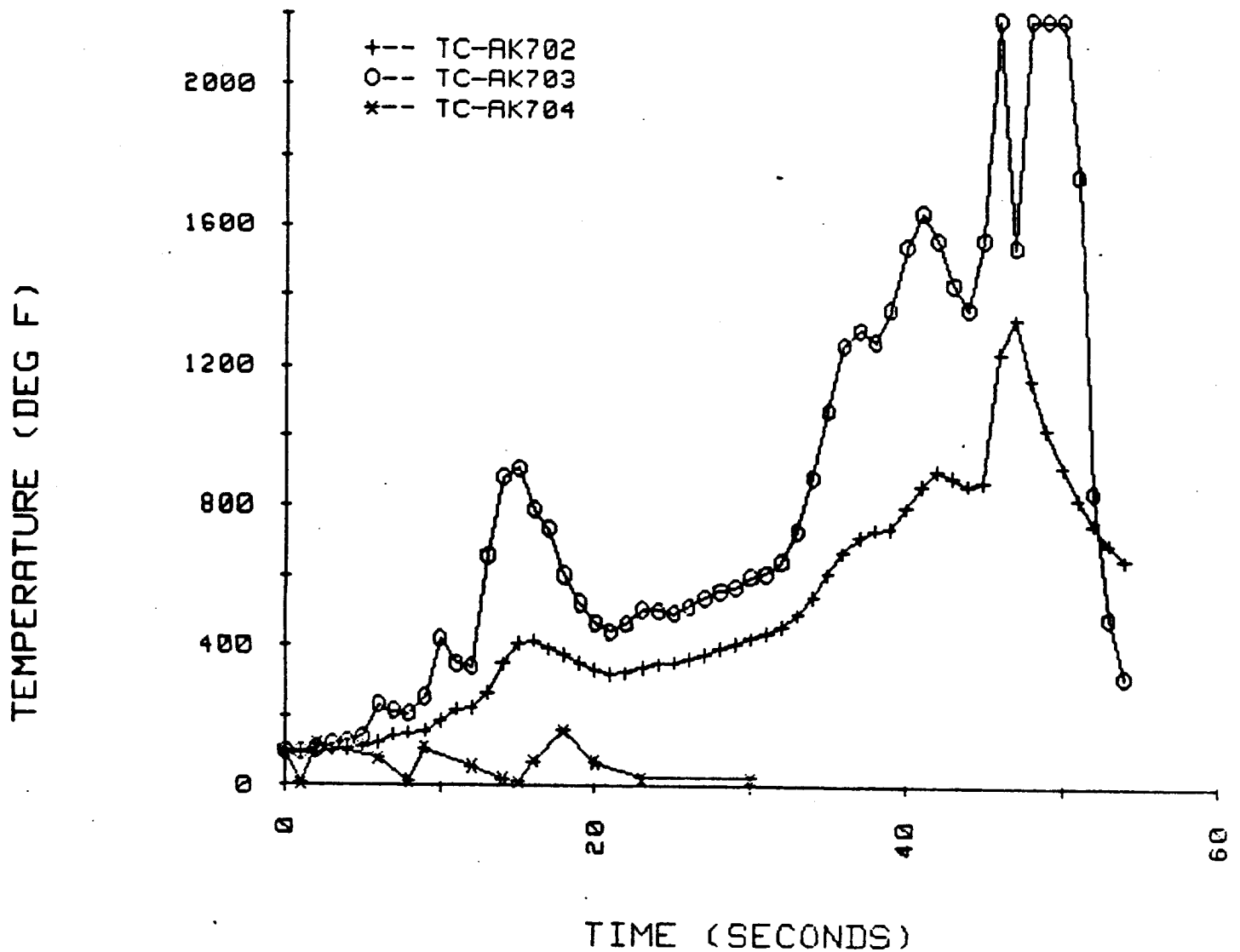
SPEED: 17000 RPM (67 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (25 PSI/SEC)



FRT #179

SAMPLES: MONEL K-500
TEST RESULTS: REACTION

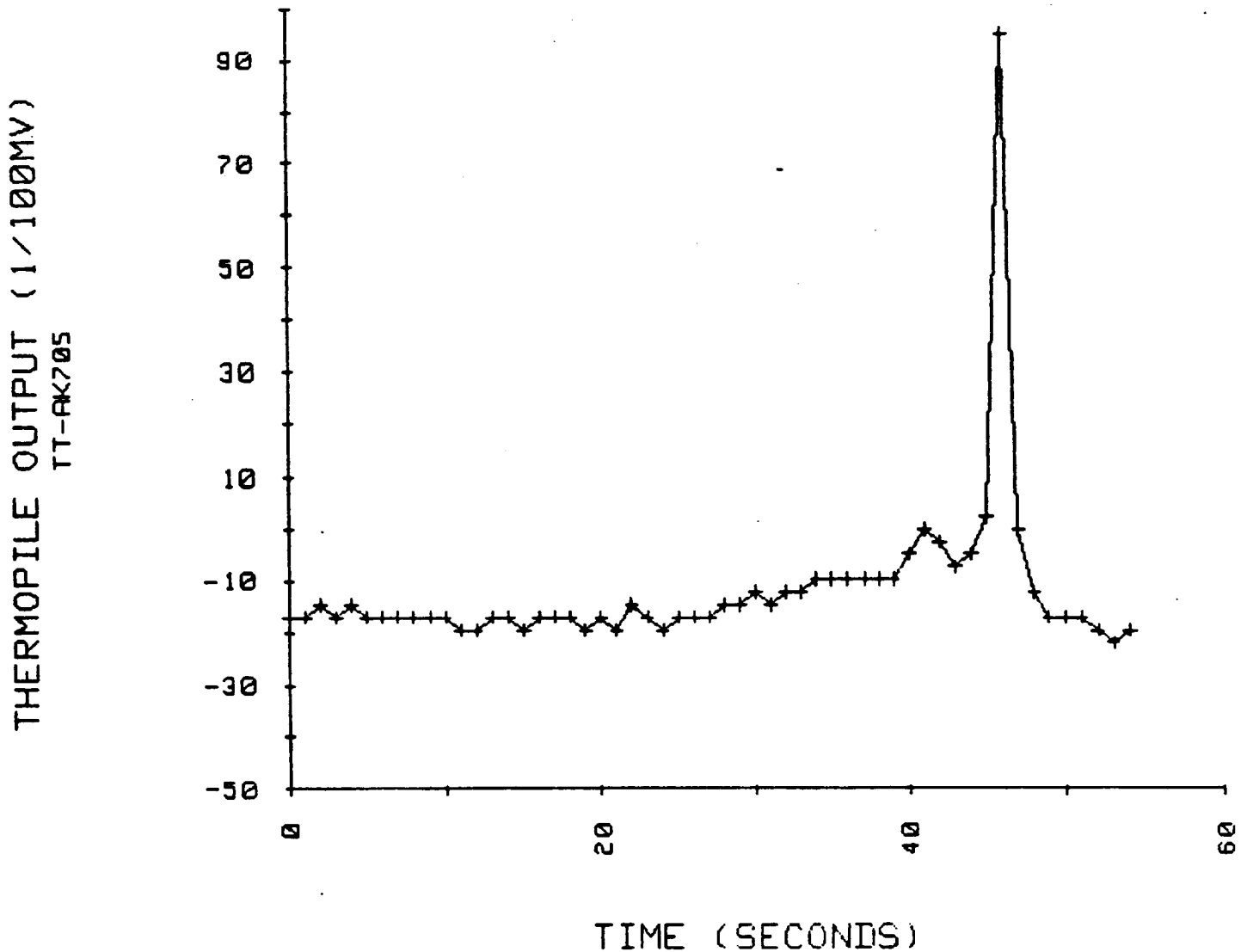
SPEED: 17000 RPM (67 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (25 PSI/SEC)



FRT #179

SAMPLES: MONEL K-500
TEST RESULTS: REACTION

SPEED: 17000 RPM (67 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (25 PSI/SEC)

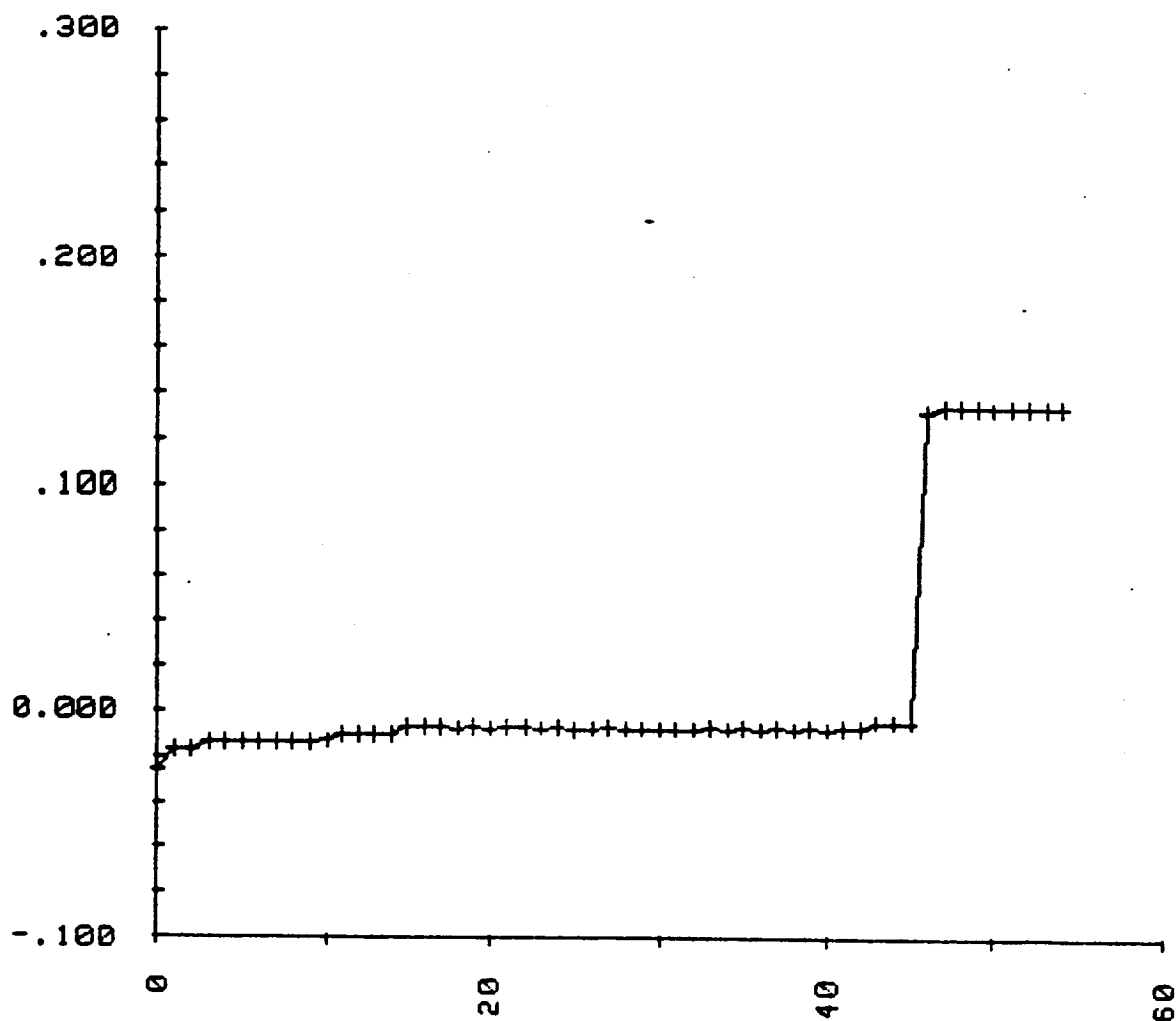


FRT #179

SAMPLES: MONEL K-500
TEST RESULTS: REACTION

SPEED: 17000 RPM (67 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (25 PSI/SEC)

SAMPLE DISPLACEMENT (INCHES)

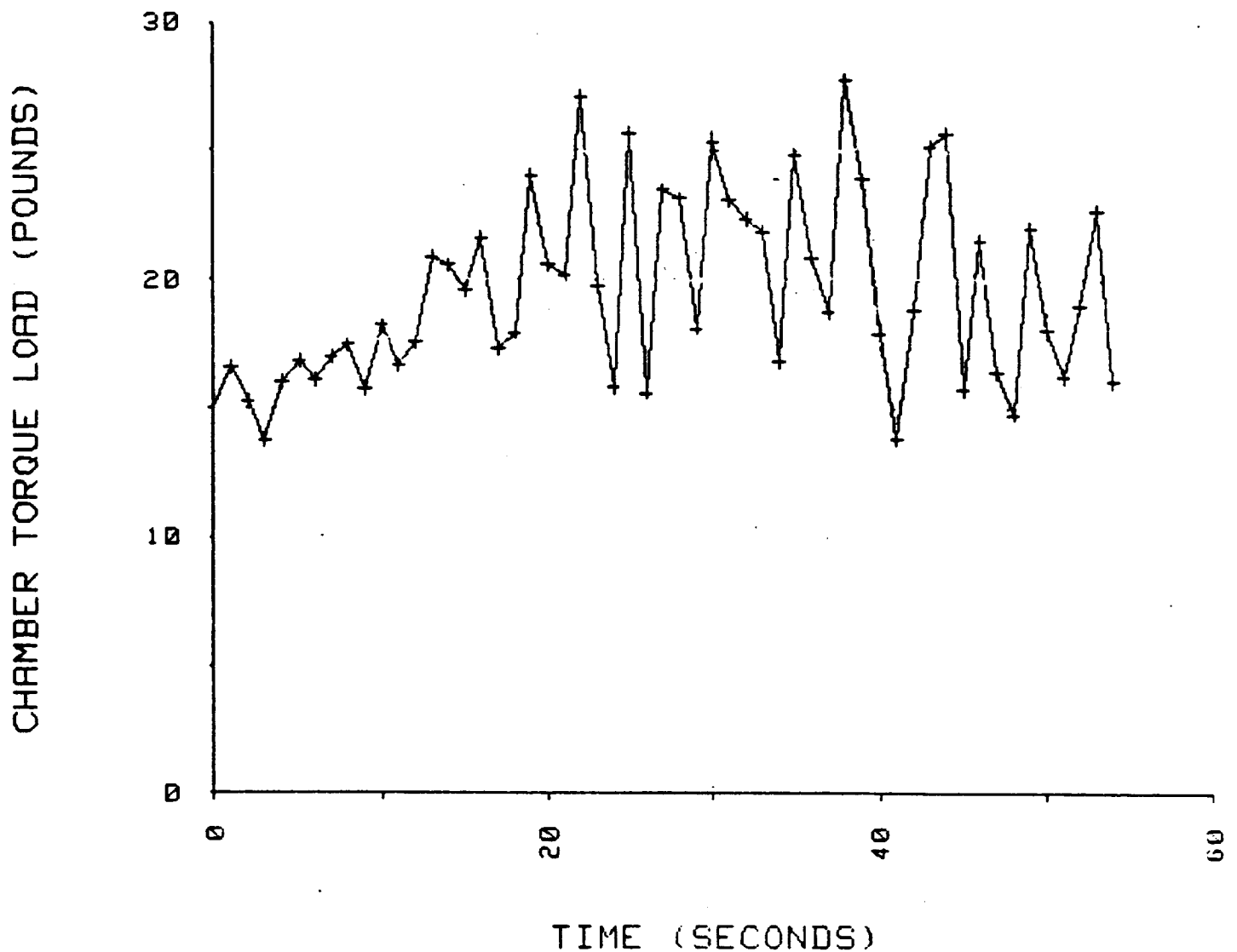


TIME (SECONDS)

FRT #179

SAMPLES: MONEL K-500
TEST RESULTS: REACTION

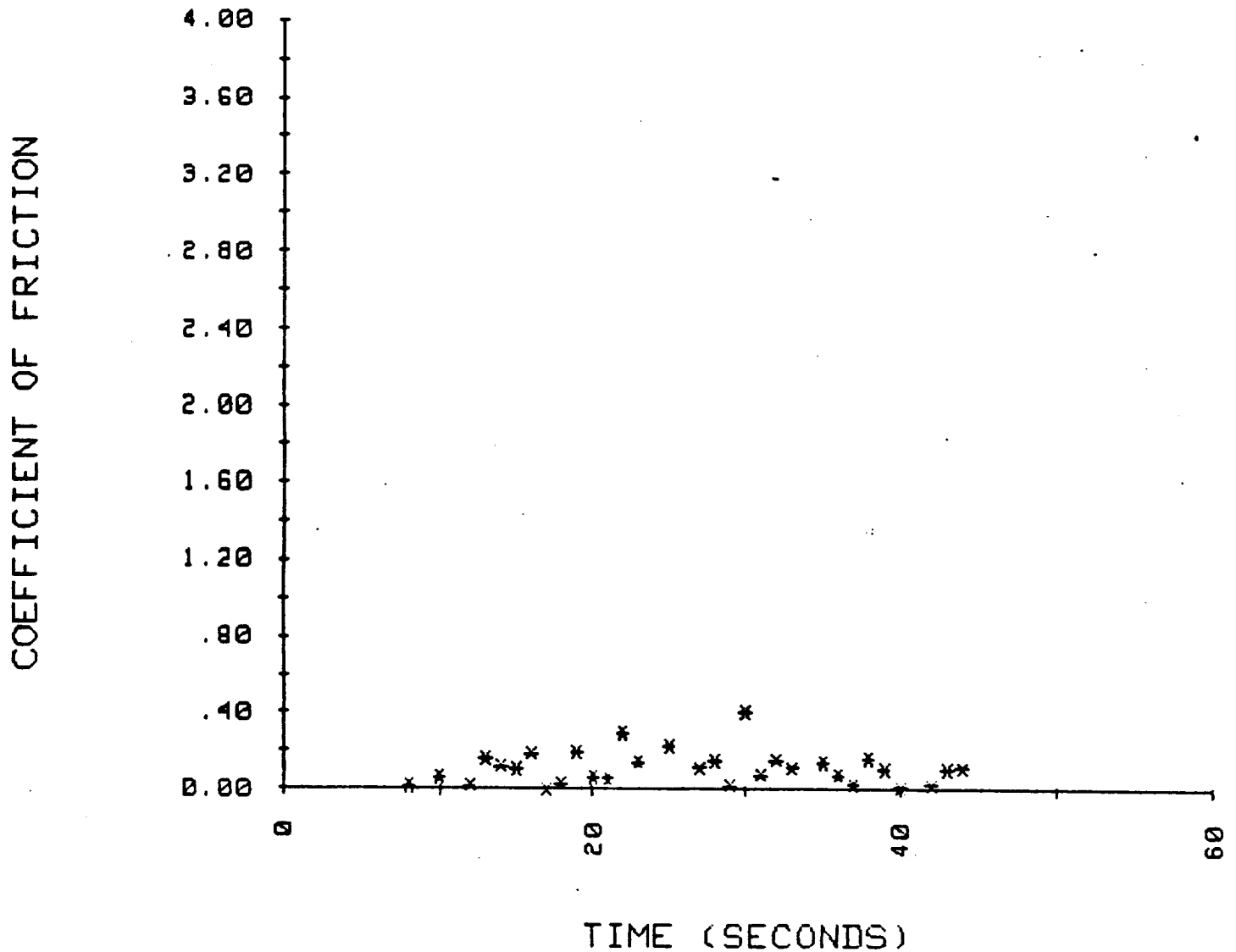
SPEED: 17000 RPM (67 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (25 PSI/SEC)



FRT #179

SAMPLES: MONEL K-500
TEST RESULTS: REACTION

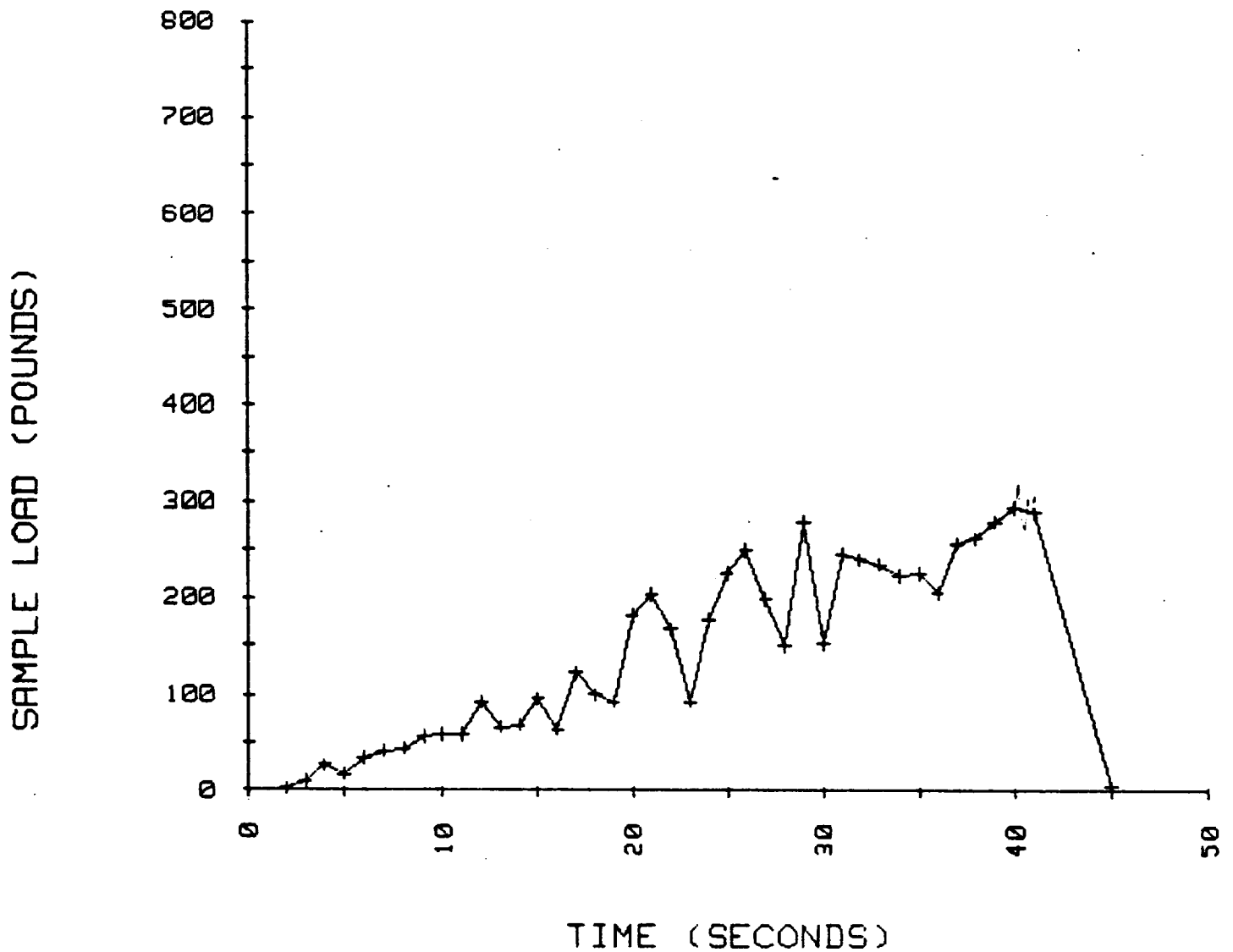
SPEED: 17000 RPM (67 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (25 PSI/SEC)



FRT #180

SAMPLES: MONEL K-500
TEST RESULTS: REACTION

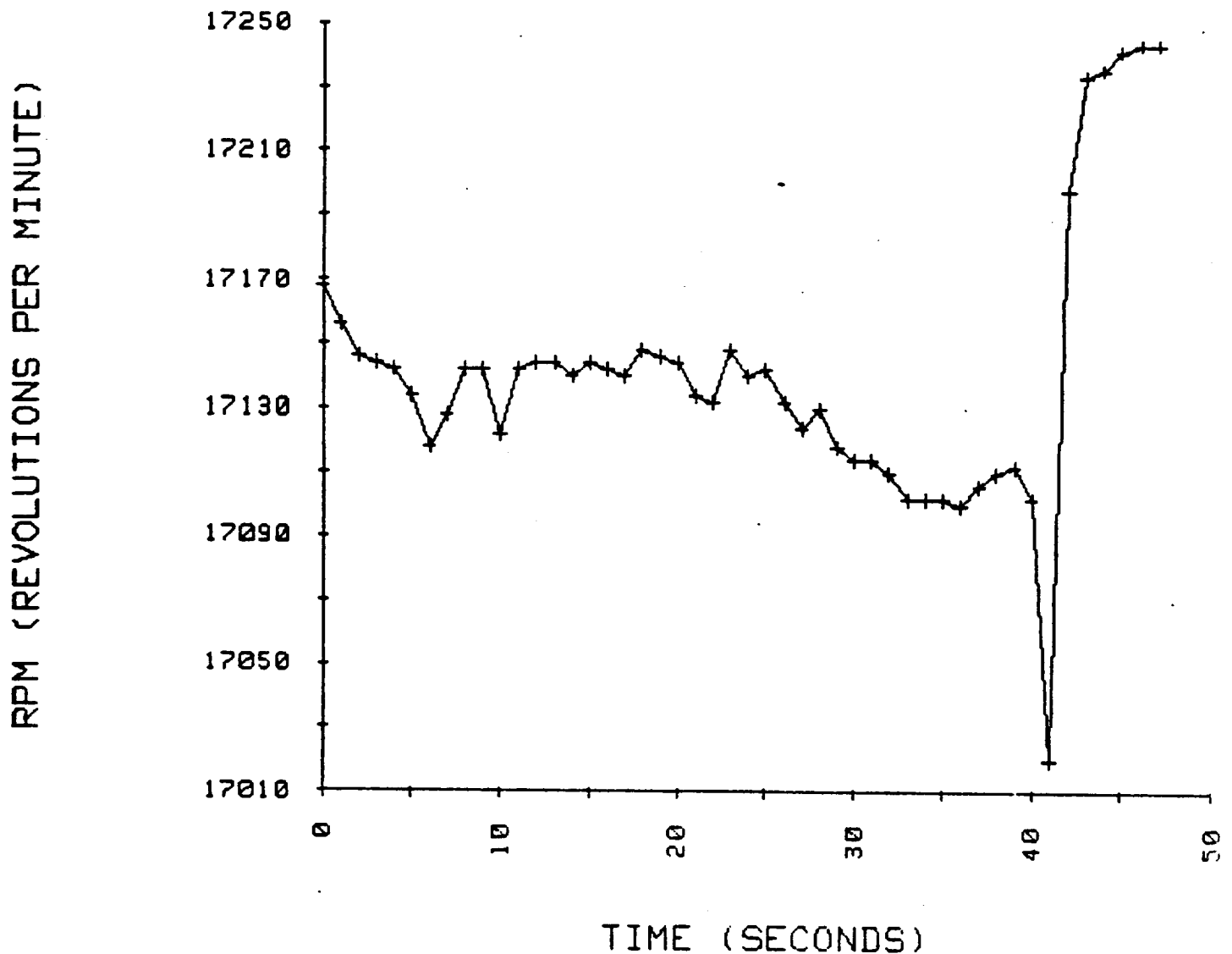
SPEED: 17000 RPM (67 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (25 PSI/SEC)



FRT #180

SAMPLES: MONEL K-500
TEST RESULTS: REACTION

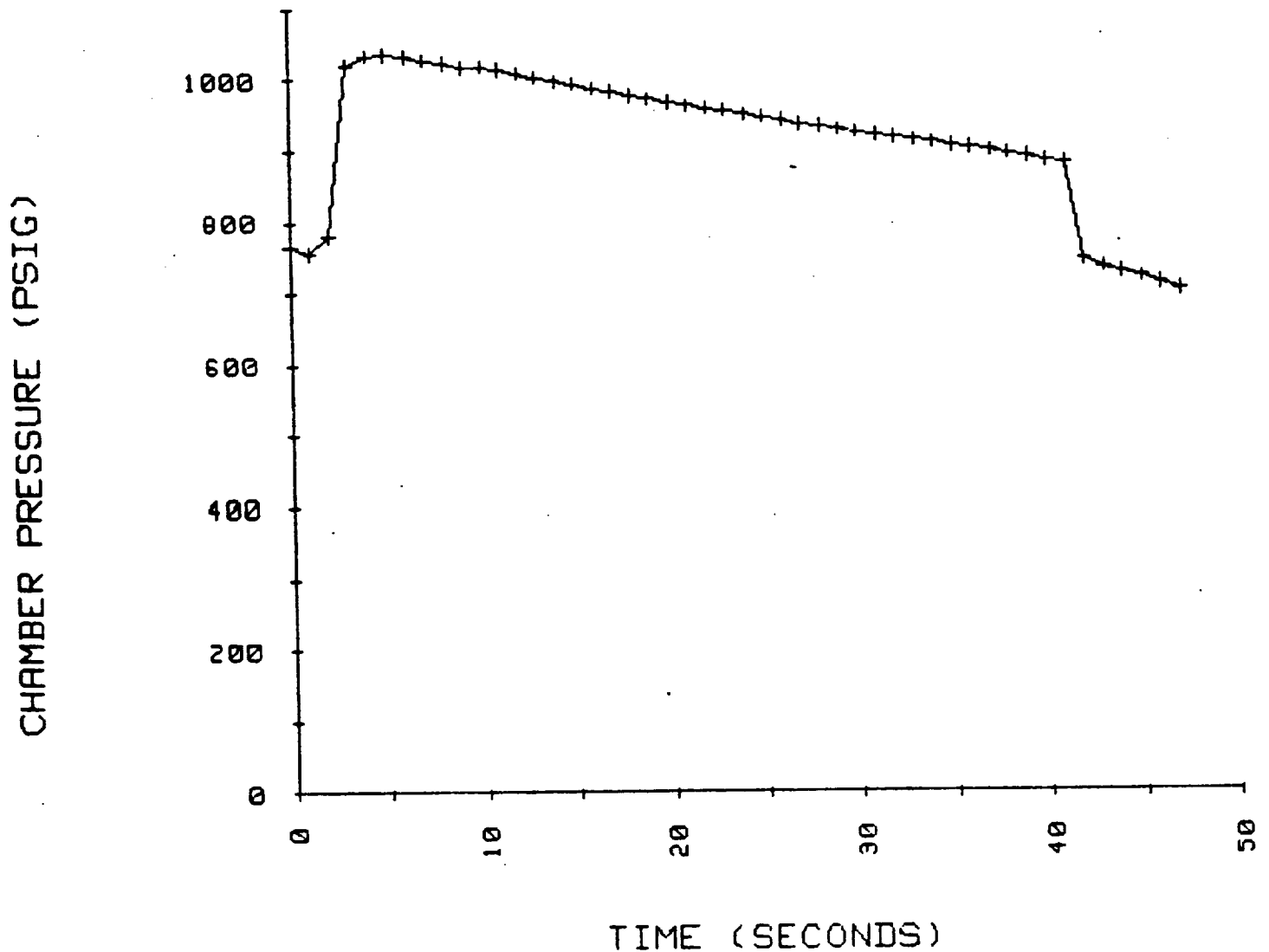
SPEED: 17000 RPM (67 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (25 PSI/SEC)



FRT #180

SAMPLES: MONEL K-500
TEST RESULTS: REACTION

SPEED: 17000 RPM (67 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (25 PSI/SEC)



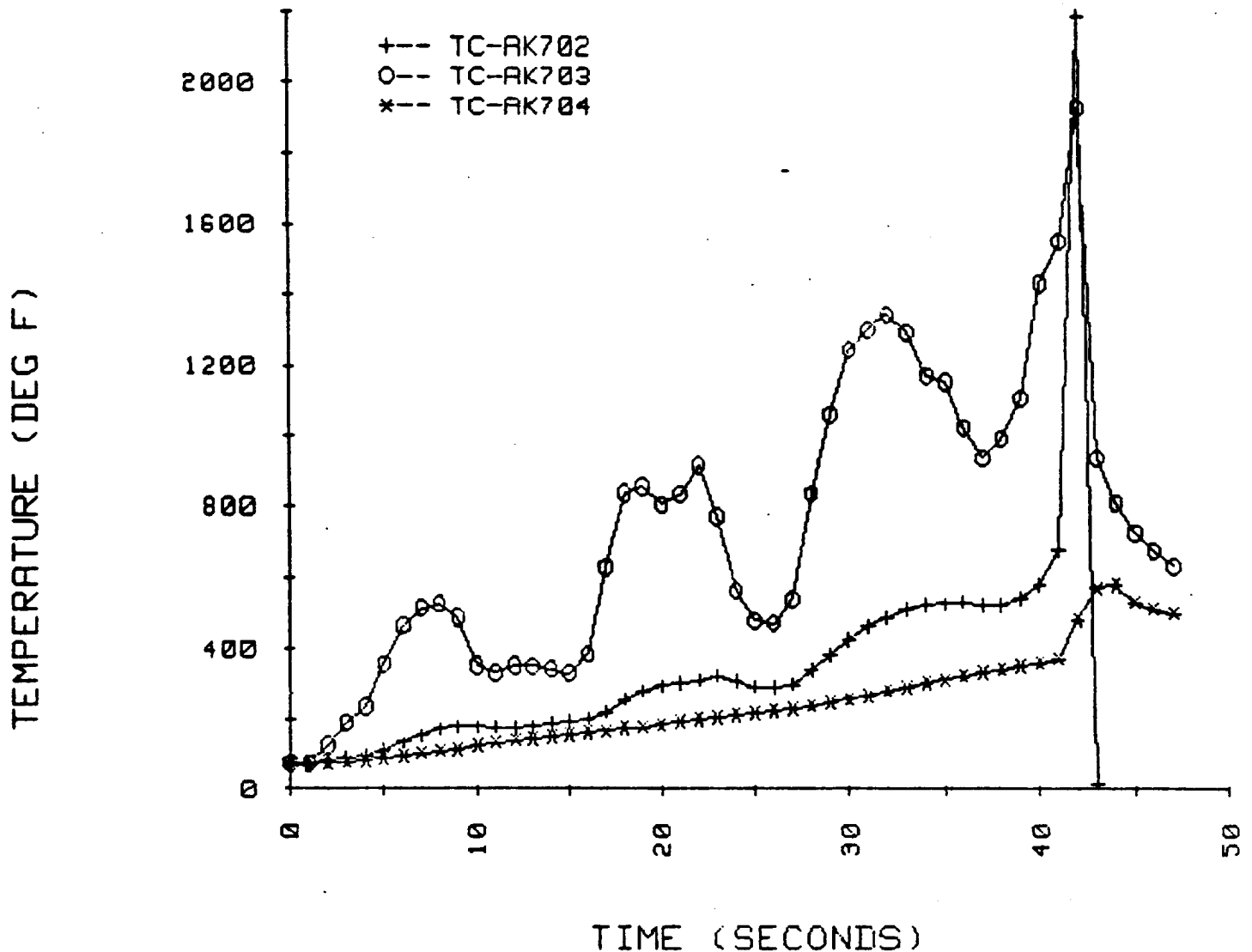
D-80

C-2

FRT #180

SAMPLES: MONEL K-500
TEST RESULTS: REACTION

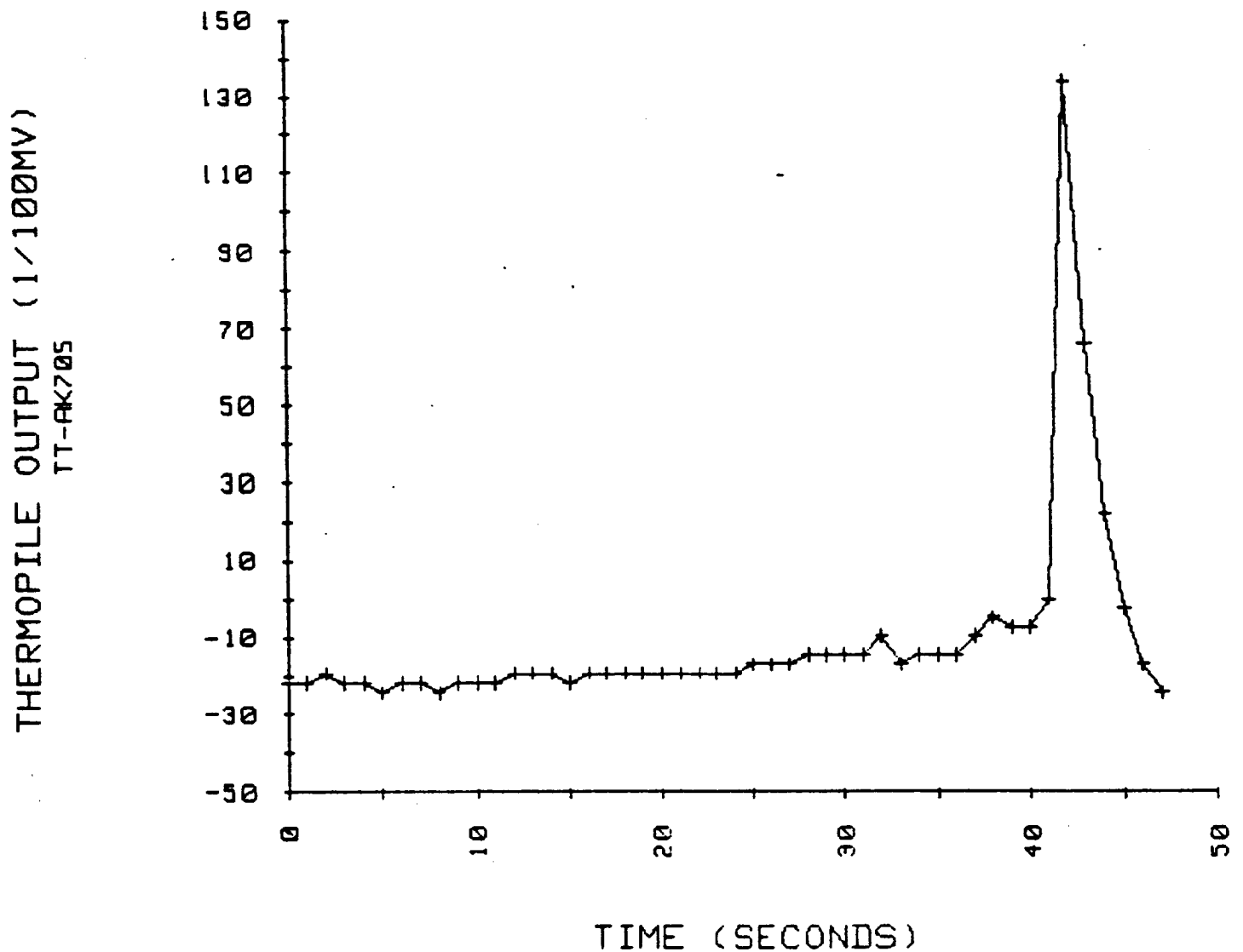
SPEED: 17000 RPM (67 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (25 PSI/SEC)



FRT #180

SAMPLES: MONEL K-500
TEST RESULTS: REACTION

SPEED: 17000 RPM (67 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (25 PSI/SEC)

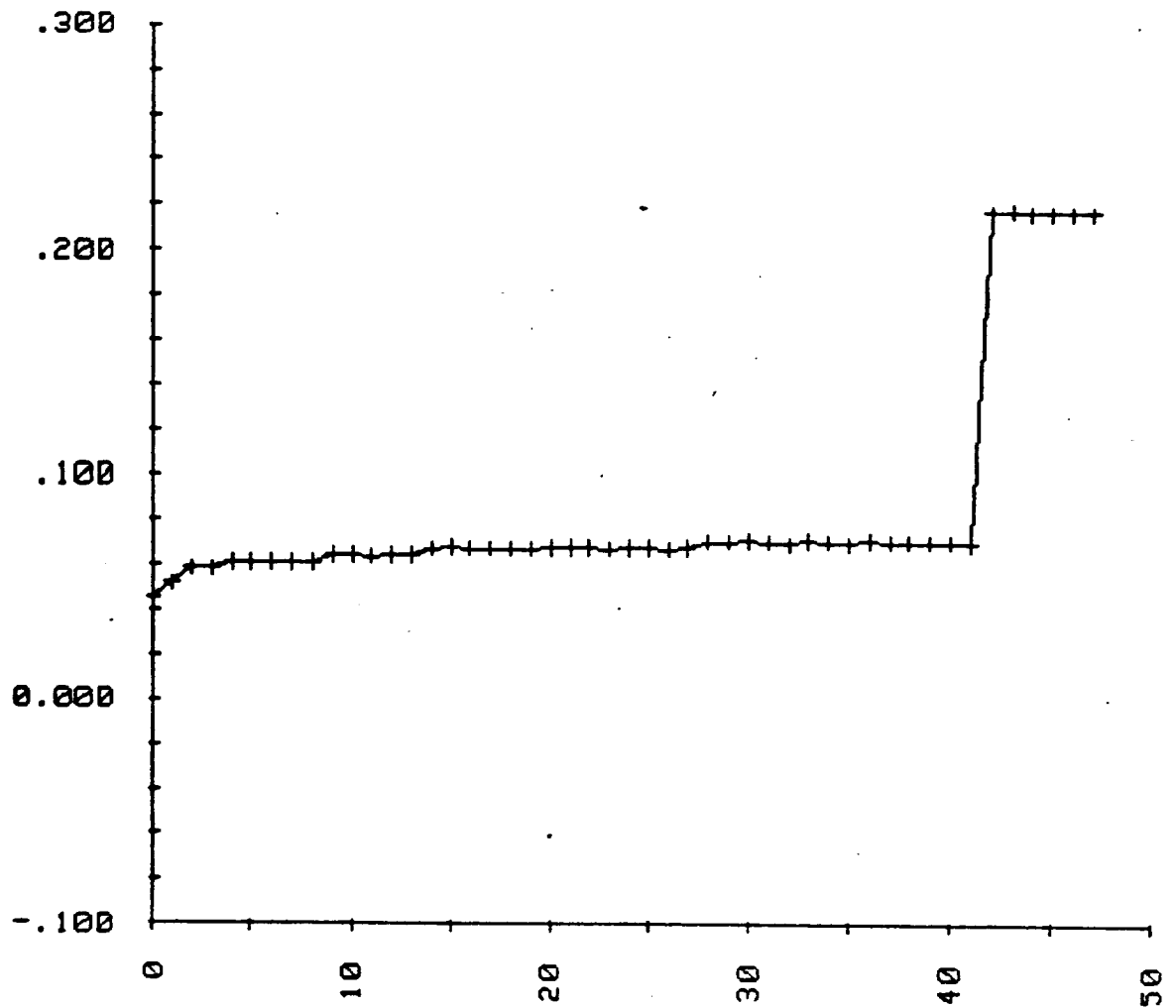


FRT #180

SAMPLES: MONEL K-500
TEST RESULTS: REACTION

SPEED: 17000 RPM (67 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (25 PSI/SEC)

SAMPLE DISPLACEMENT (INCHES)

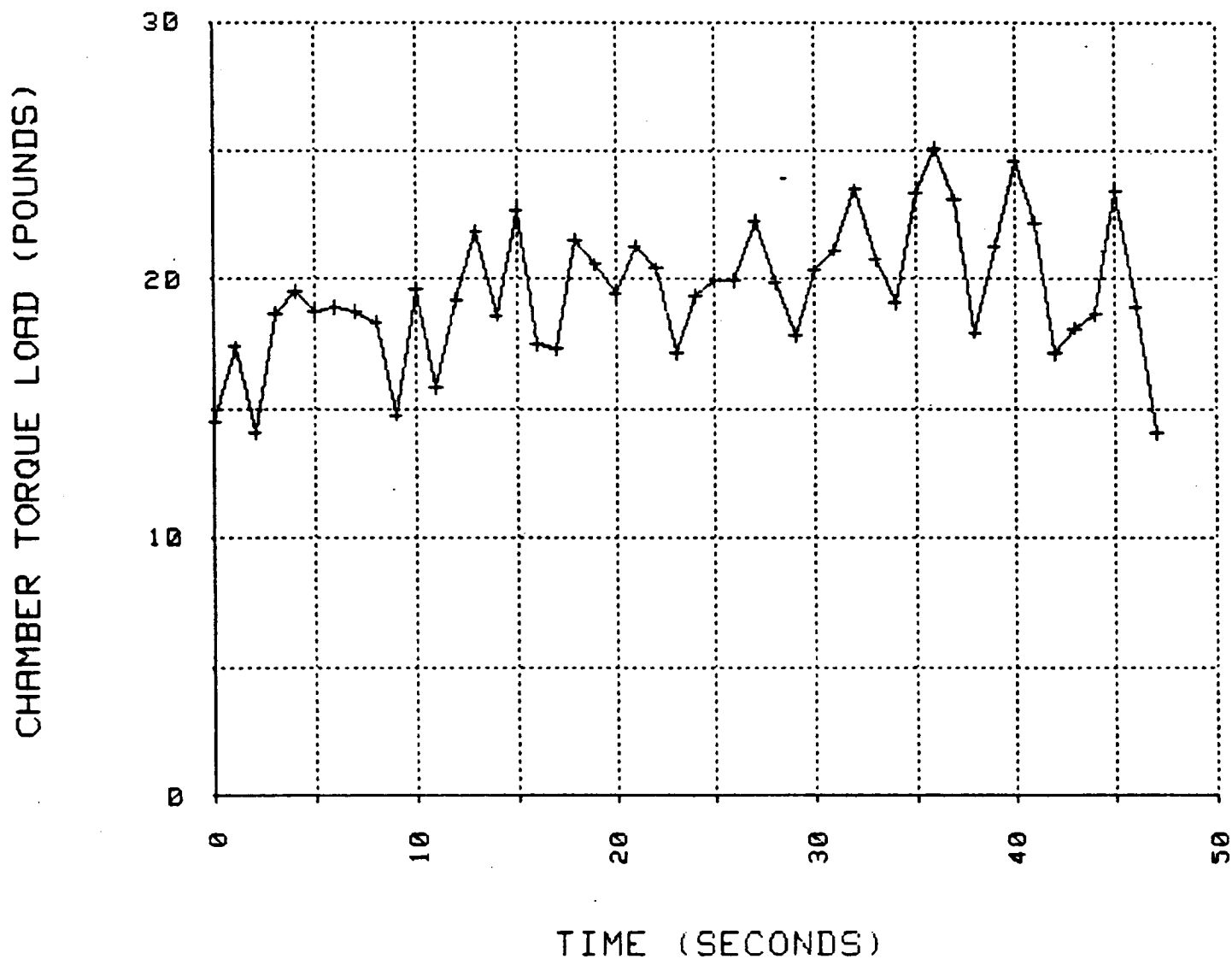


TIME (SECONDS)

FRT #180

SAMPLES: MONEL K-500
TEST RESULTS: REACTION

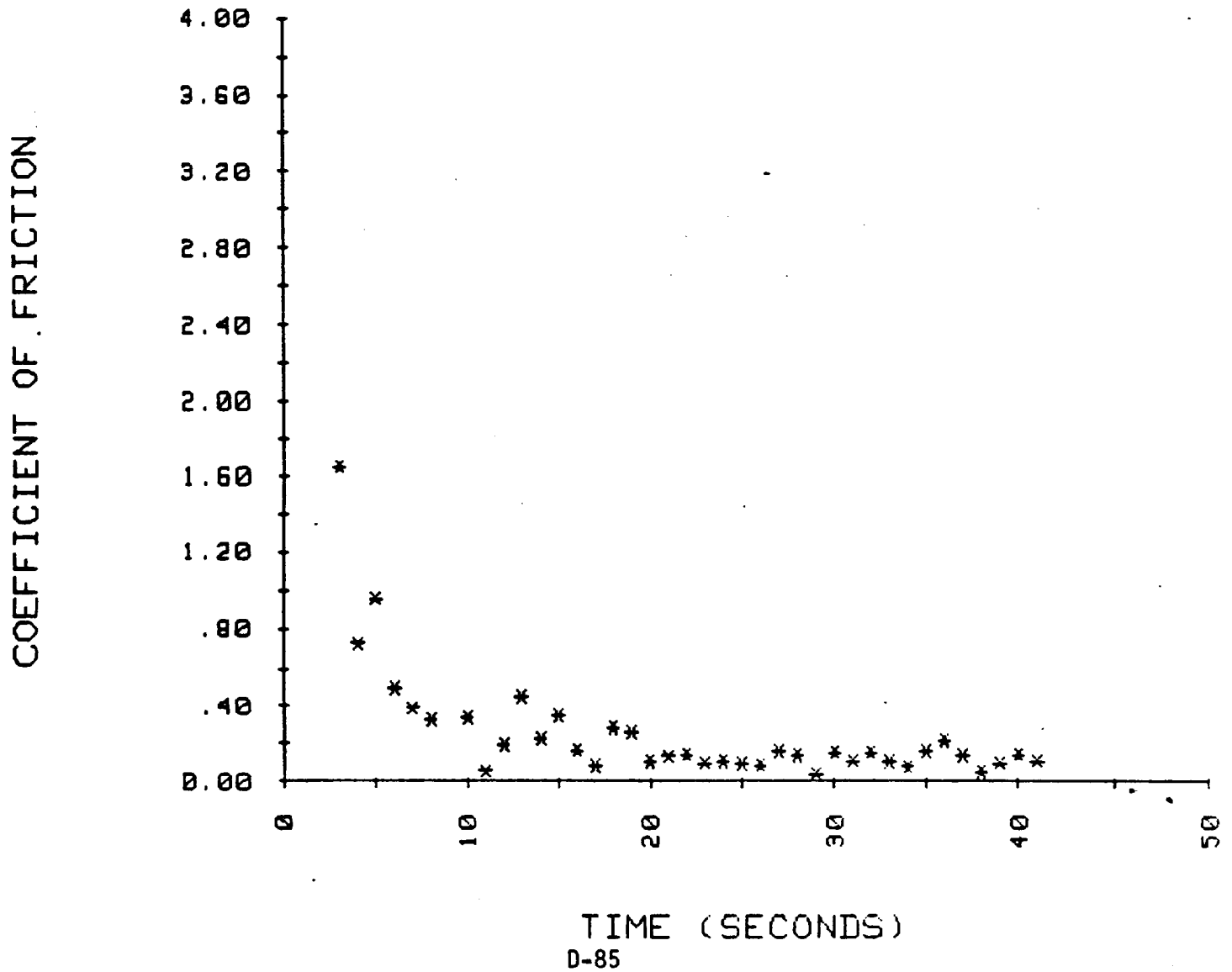
SPEED: 17000 RPM (67 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (25 PSI/SEC)



FRT #180

SAMPLES: MONEL K-500
TEST RESULTS: REACTION

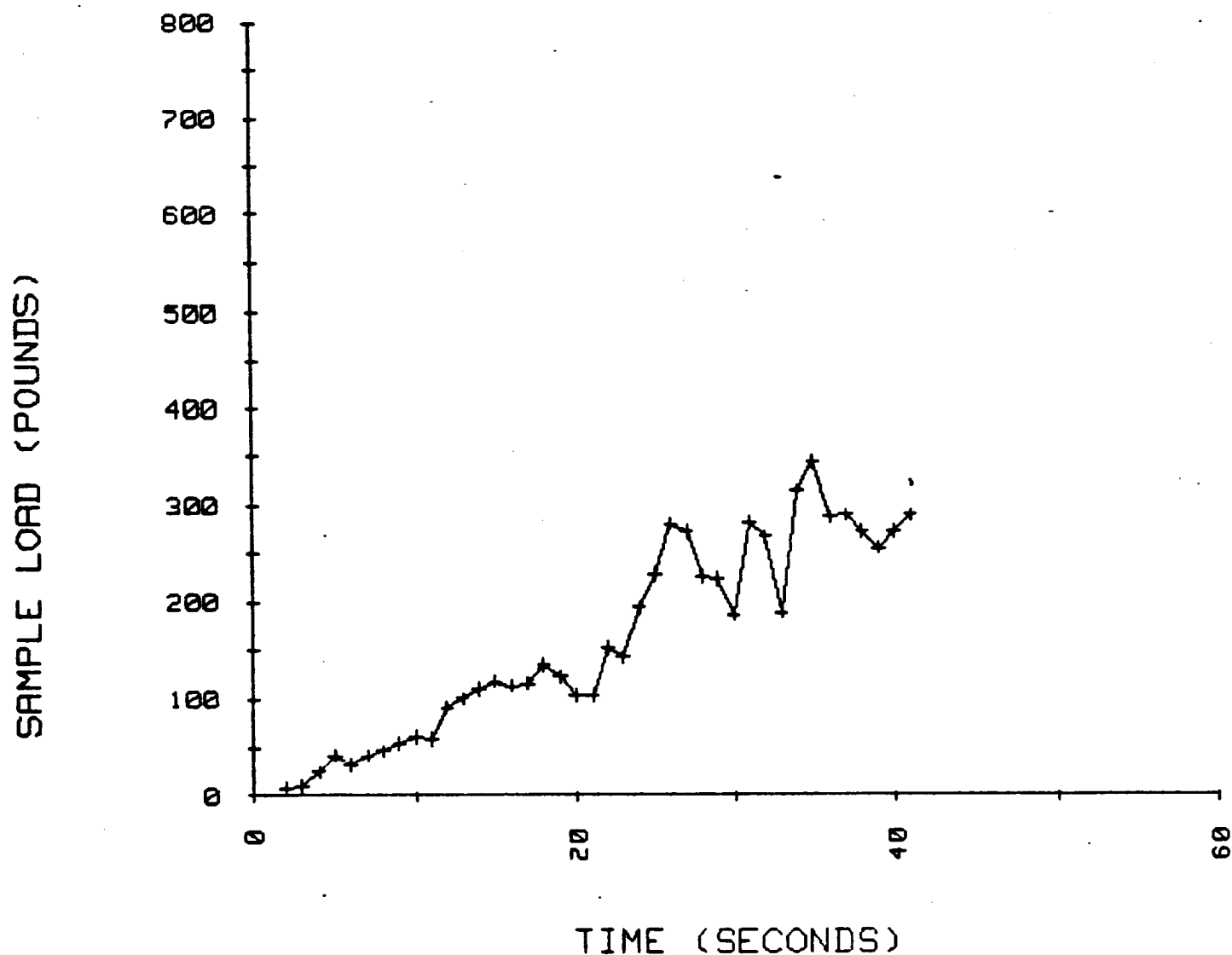
SPEED: 17000 RPM (67 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (25 PSI/SEC)



FRT #181

SAMPLES: MONEL K-500
TEST RESULTS: REACTION

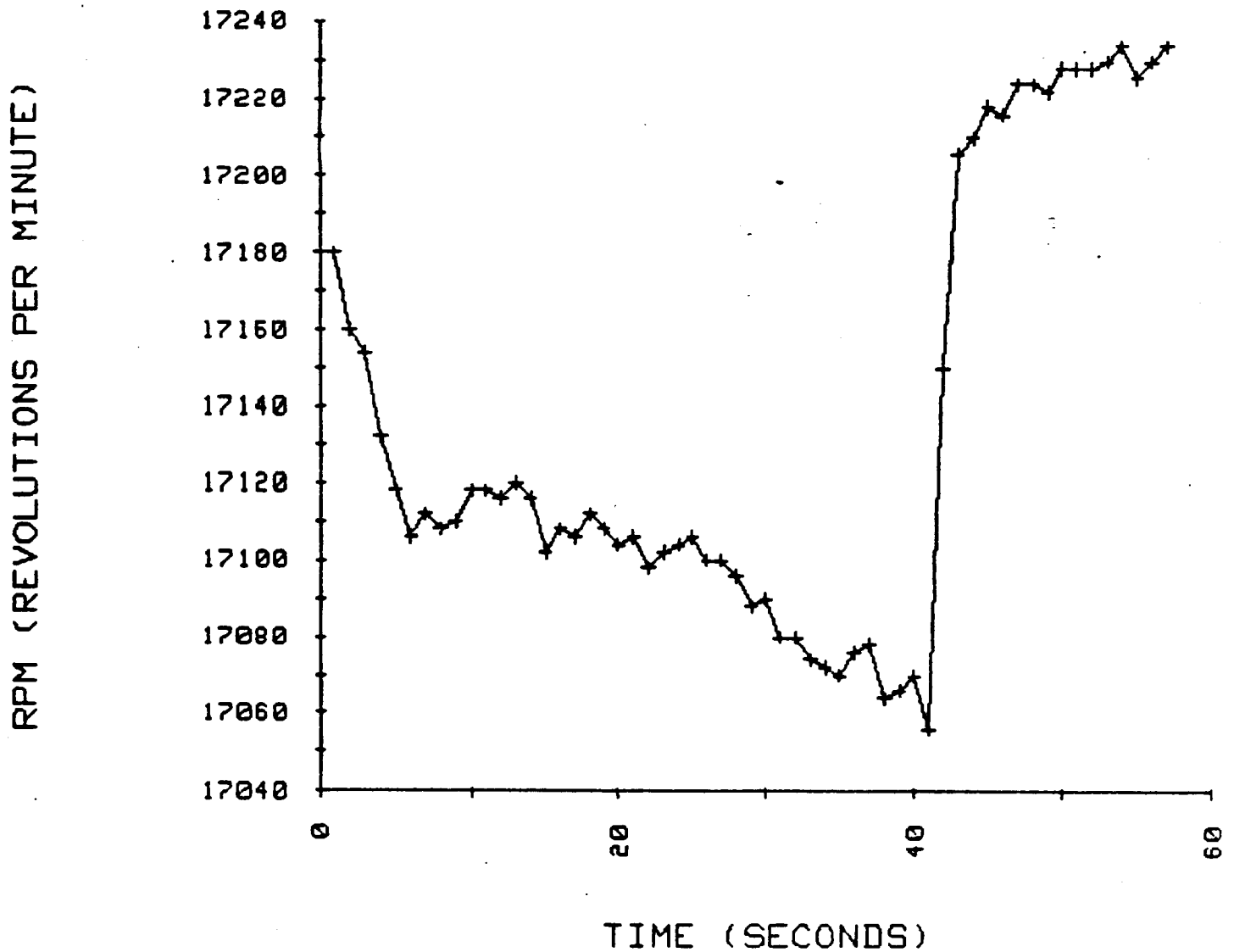
SPEED: 17000 RPM (67 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (25 PSI/SEC)



FRT #181

SAMPLES: MONEL K-500
TEST RESULTS: REACTION

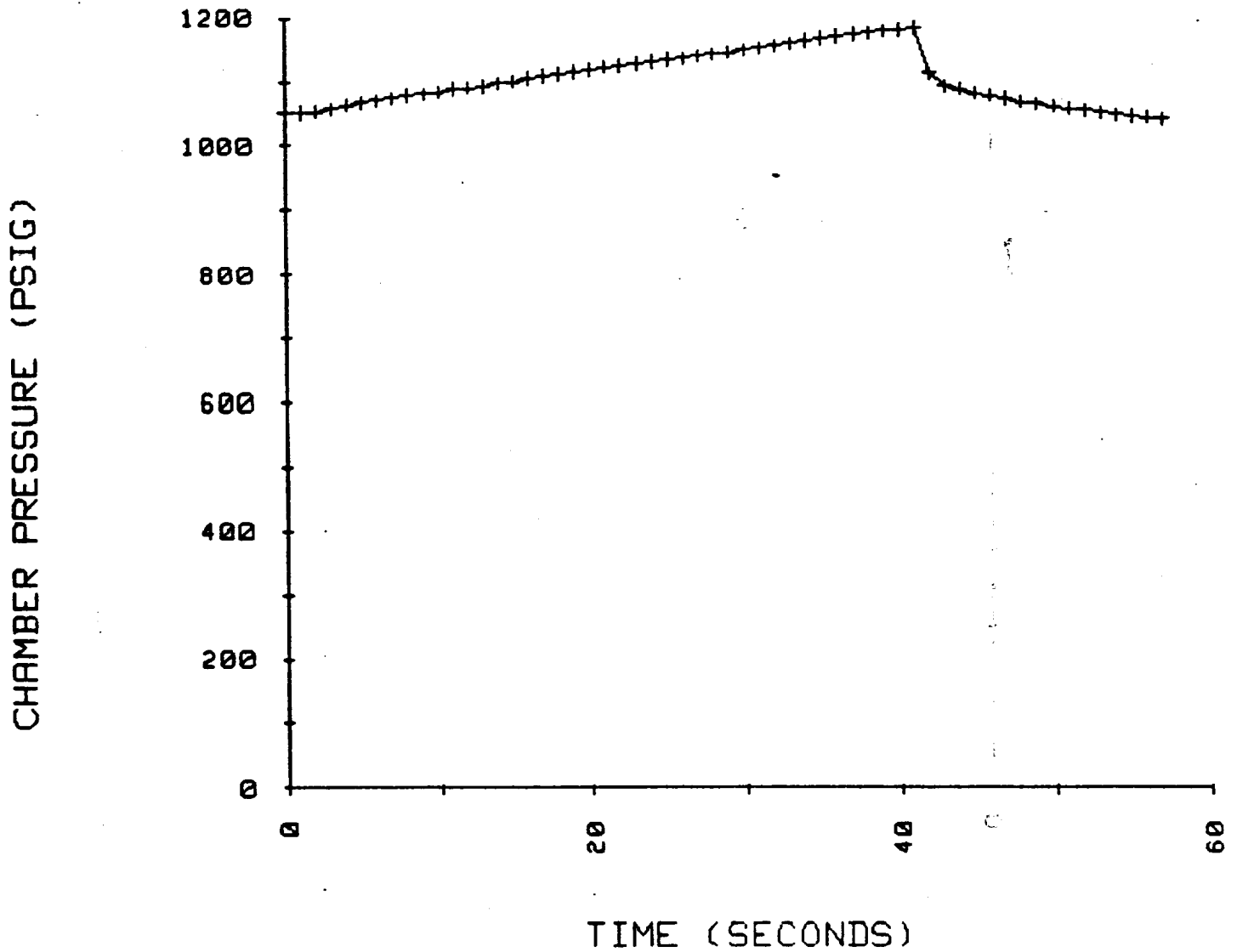
SPEED: 17000 RPM (67 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (25 PSI/SEC)



FRT #181

SAMPLES: MONEL K-500
TEST RESULTS: REACTION

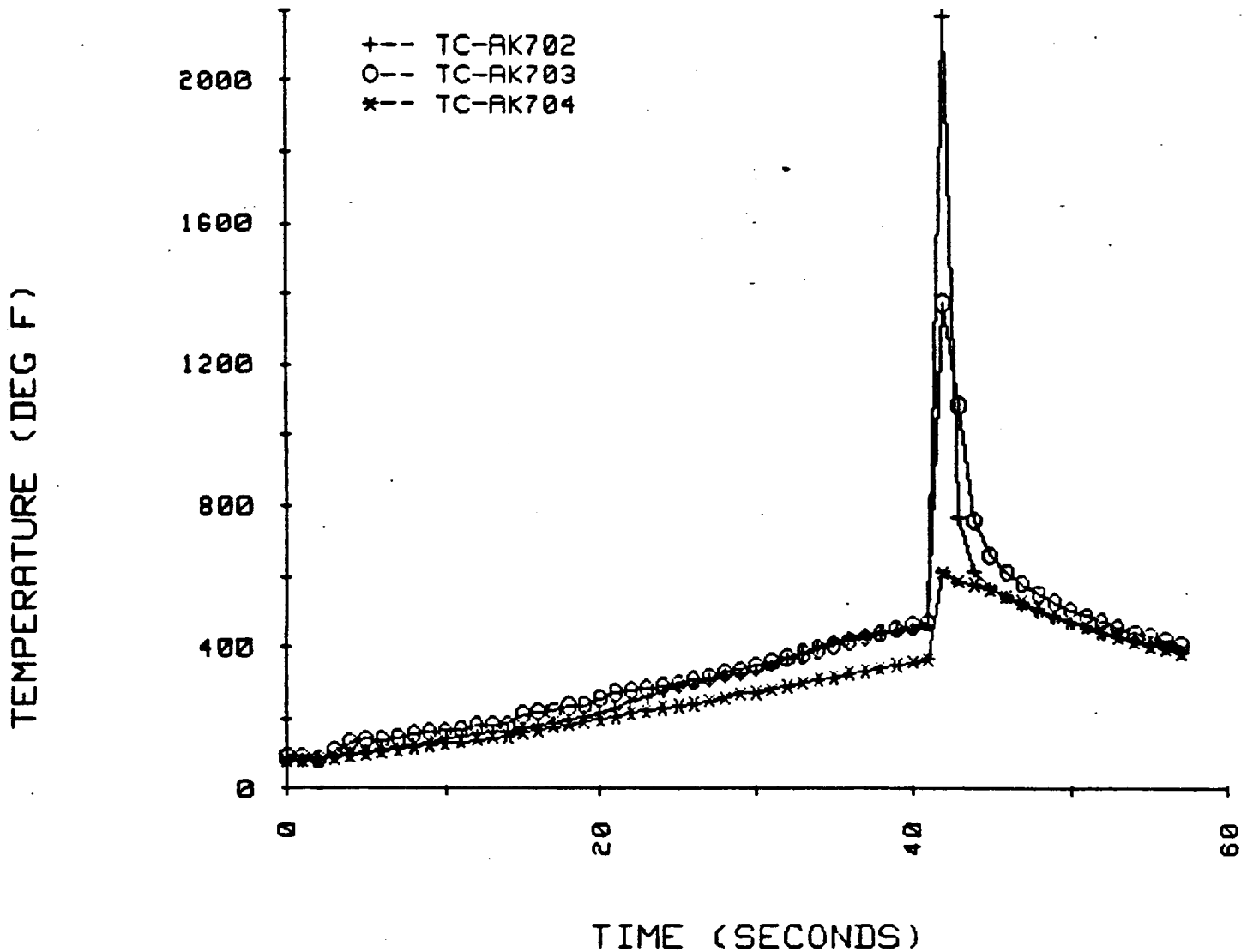
SPEED: 17000 RPM (67 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (25 PSI/SEC)



FRT #181

SAMPLES: MONEL K-500
TEST RESULTS: REACTION

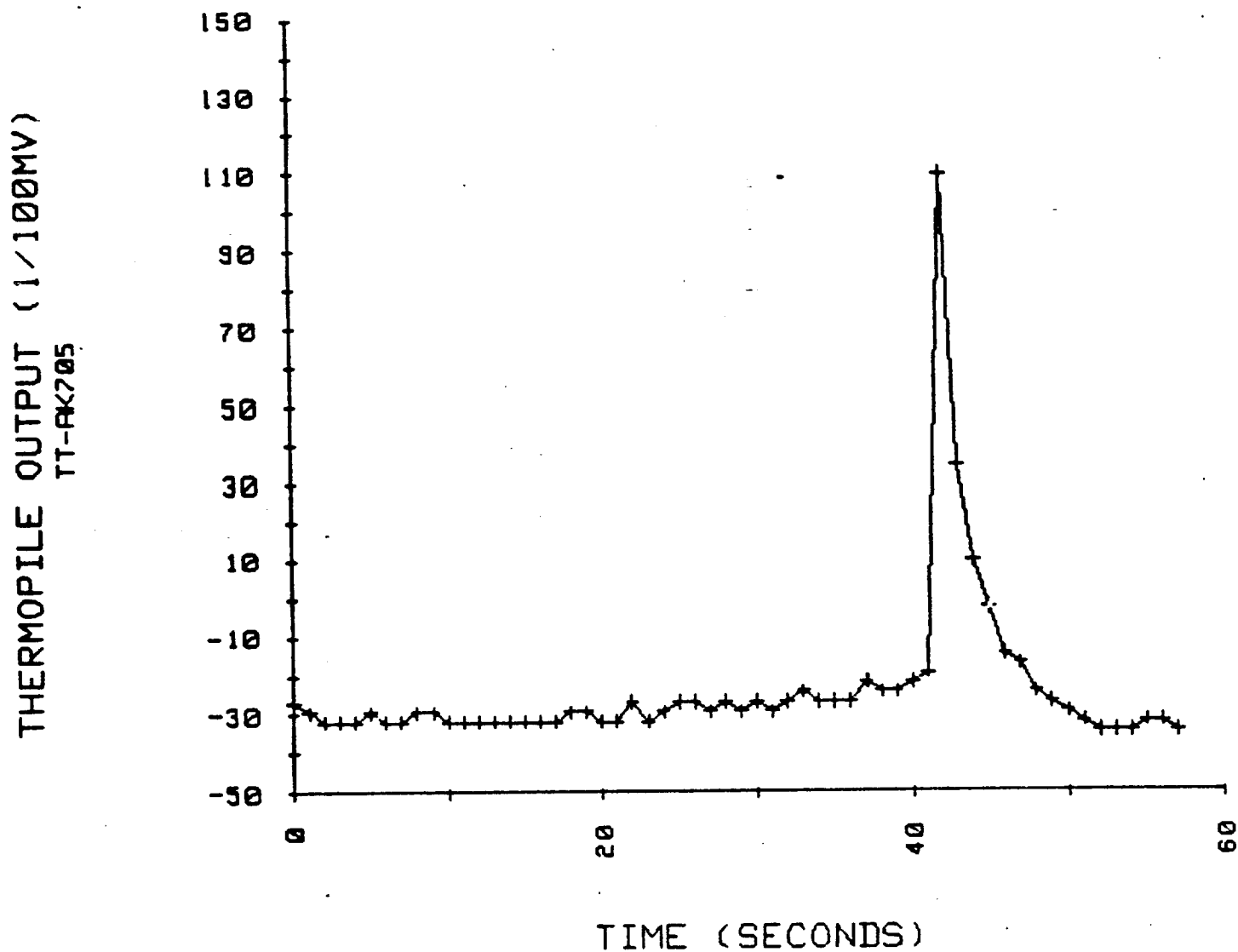
SPEED: 17000 RPM (67 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (25 PSI/SEC)



FRT #181

SAMPLES: MONEL K-500
TEST RESULTS: REACTION

SPEED: 17000 RPM (67 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (25 PSI/SEC)



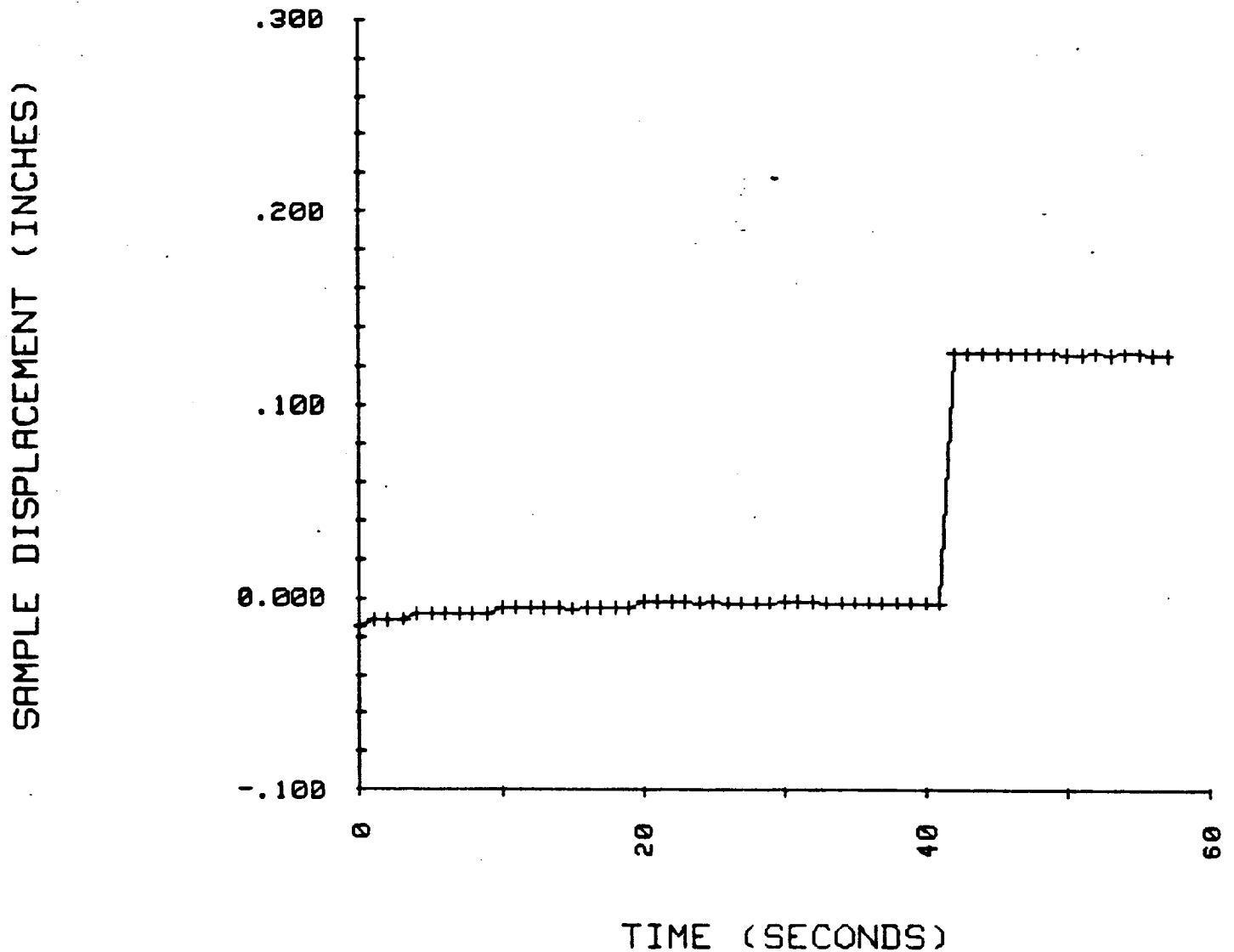
PRECEDING PAGE BLANK NOT FILMED

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FRT #181

SAMPLES: MONEL K-500
TEST RESULTS: REACTION

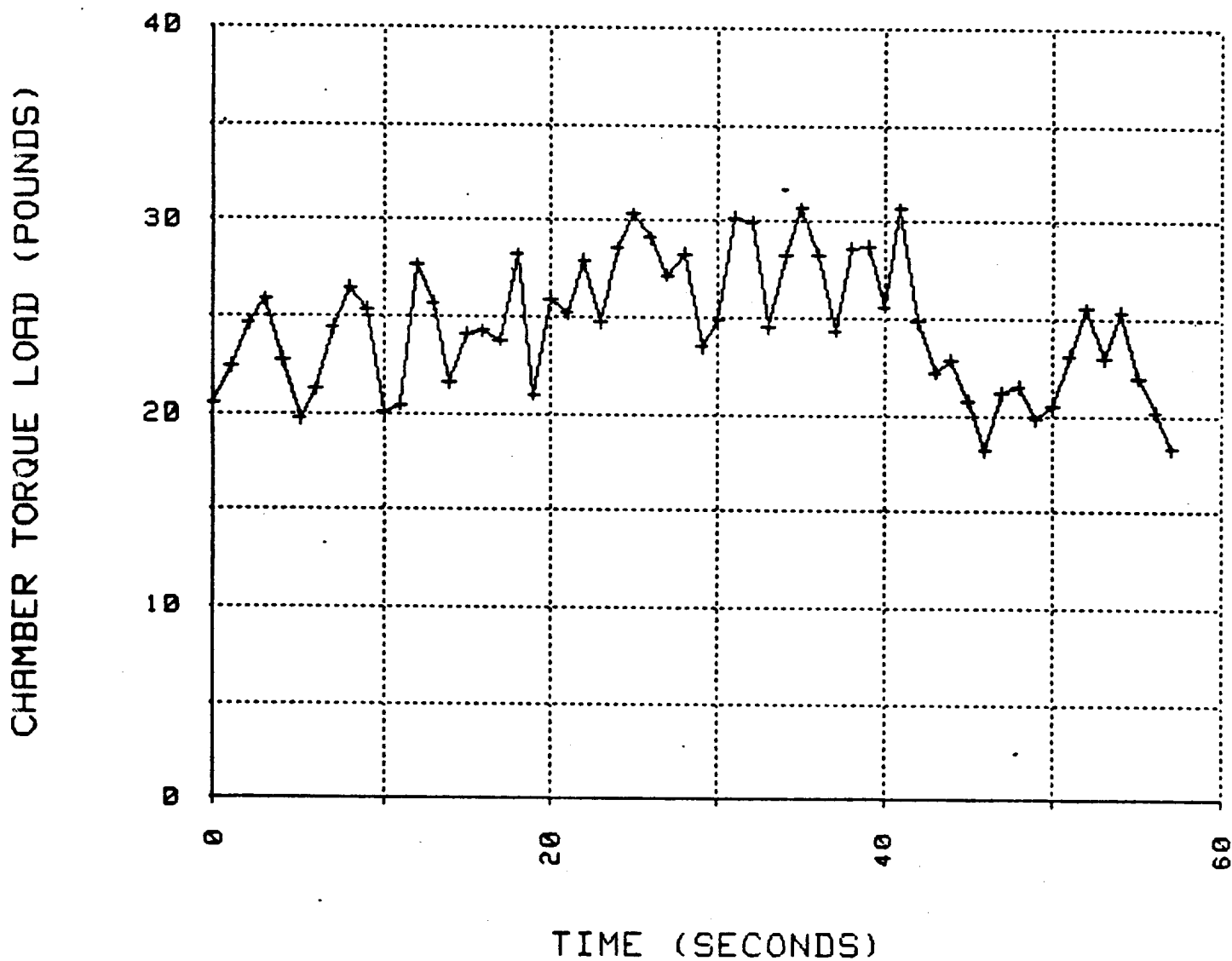
SPEED: 17000 RPM (67 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (25 PSI/SEC)



FRT #181

SAMPLES: MONEL K-500
TEST RESULTS: REACTION

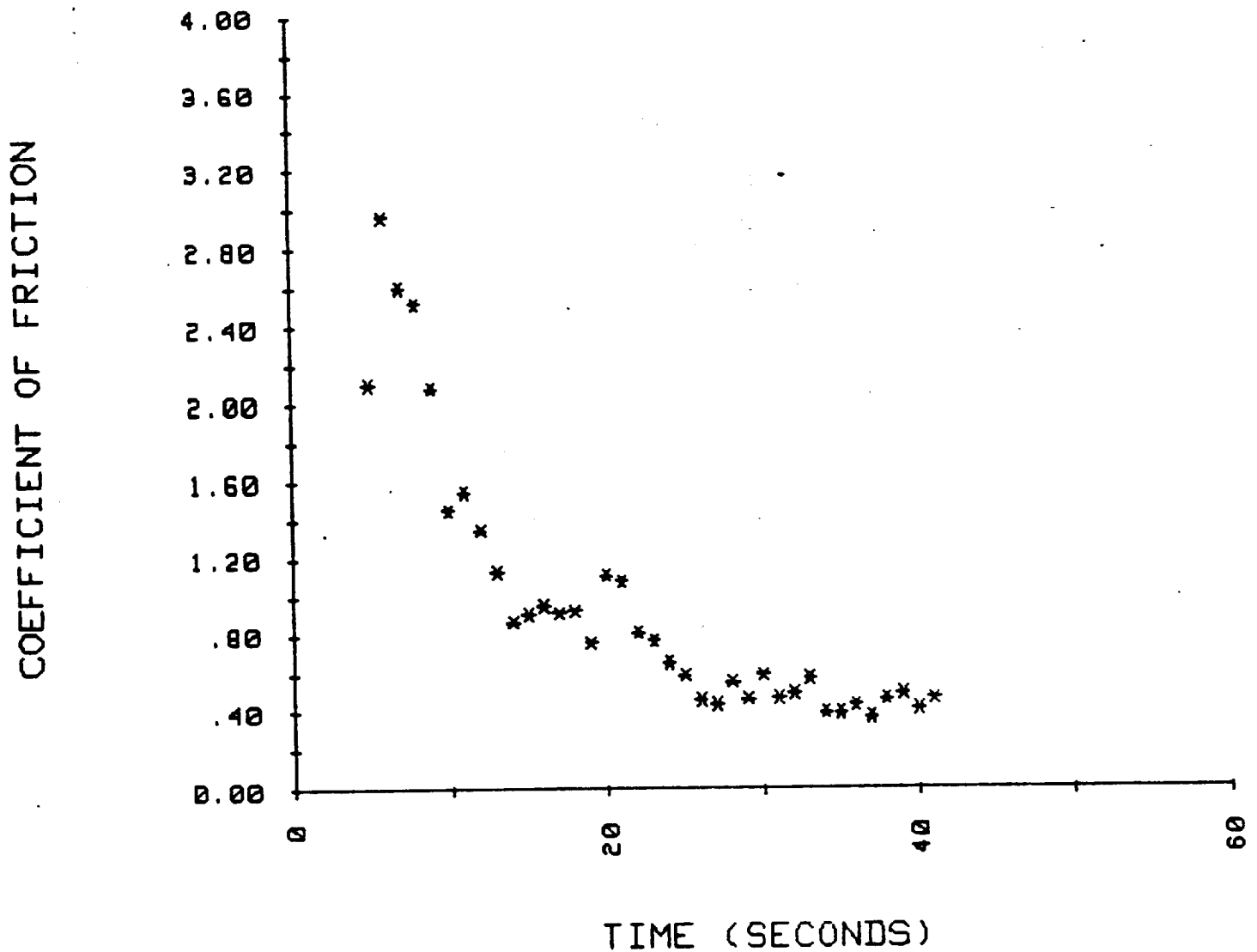
SPEED: 17000 RPM (67 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (25 PSI/SEC)



FRT #181

SAMPLES: MONEL K-500
TEST RESULTS: REACTION

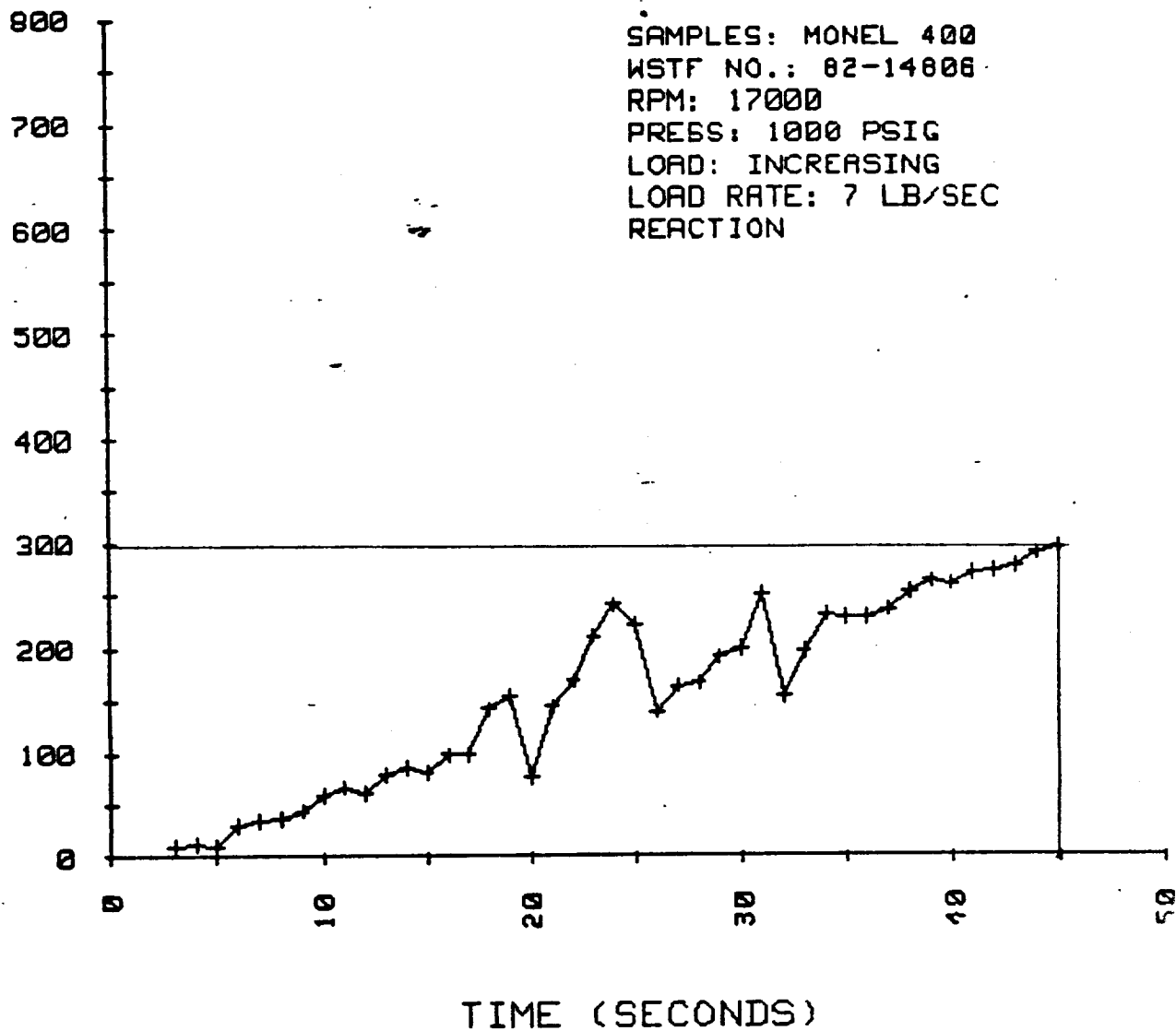
SPEED: 17000 RPM (67 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (25 PSI/SEC)



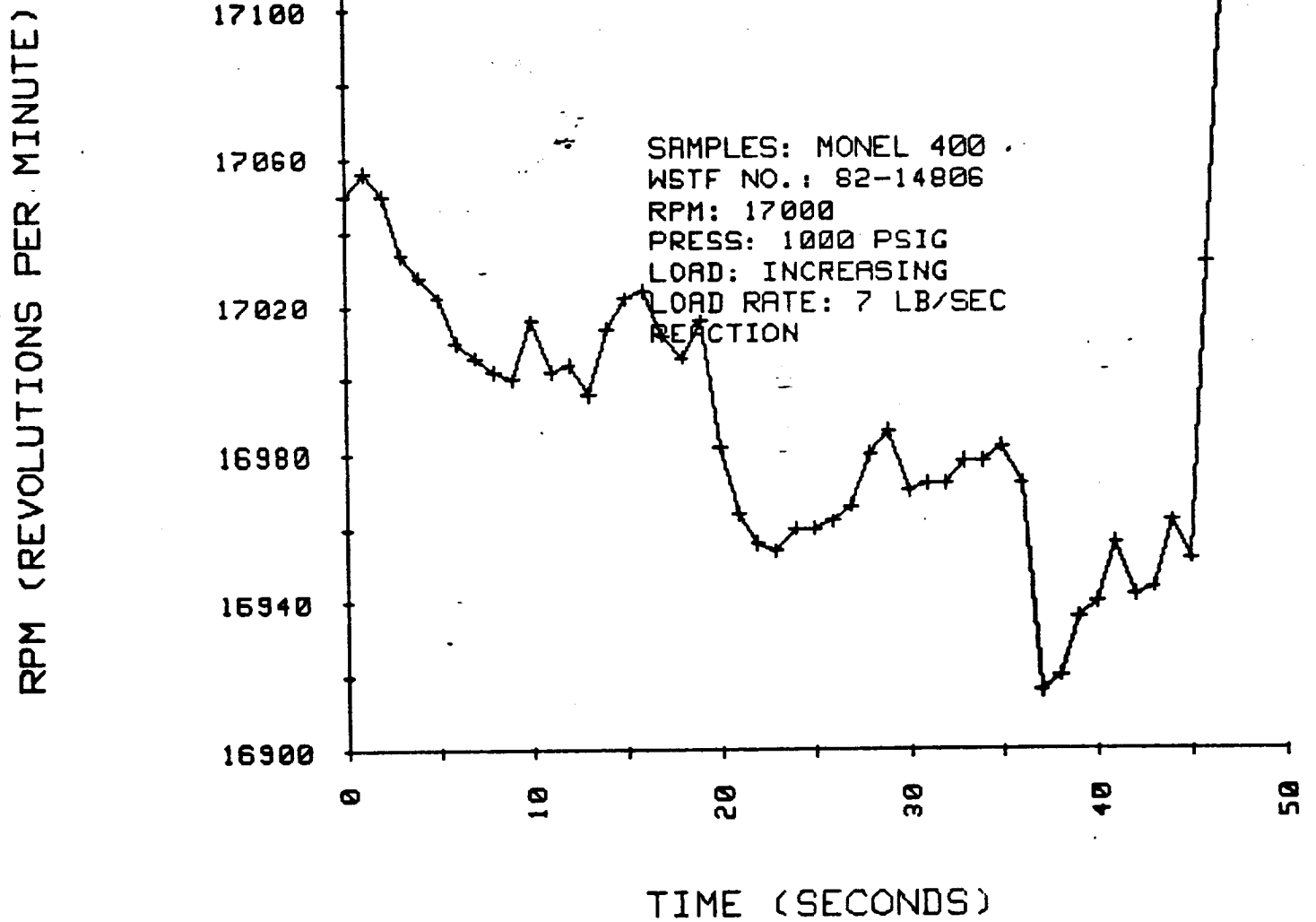
FRT #162 TEST #2 6/27/83

SAMPLES: MONEL 400
WSTF NO.: 82-14808
RPM: 17000
PRESS: 1000 PSIG
LOAD: INCREASING
LOAD RATE: 7 LB/SEC
REACTION

SAMPLE LOAD (POUNDS)

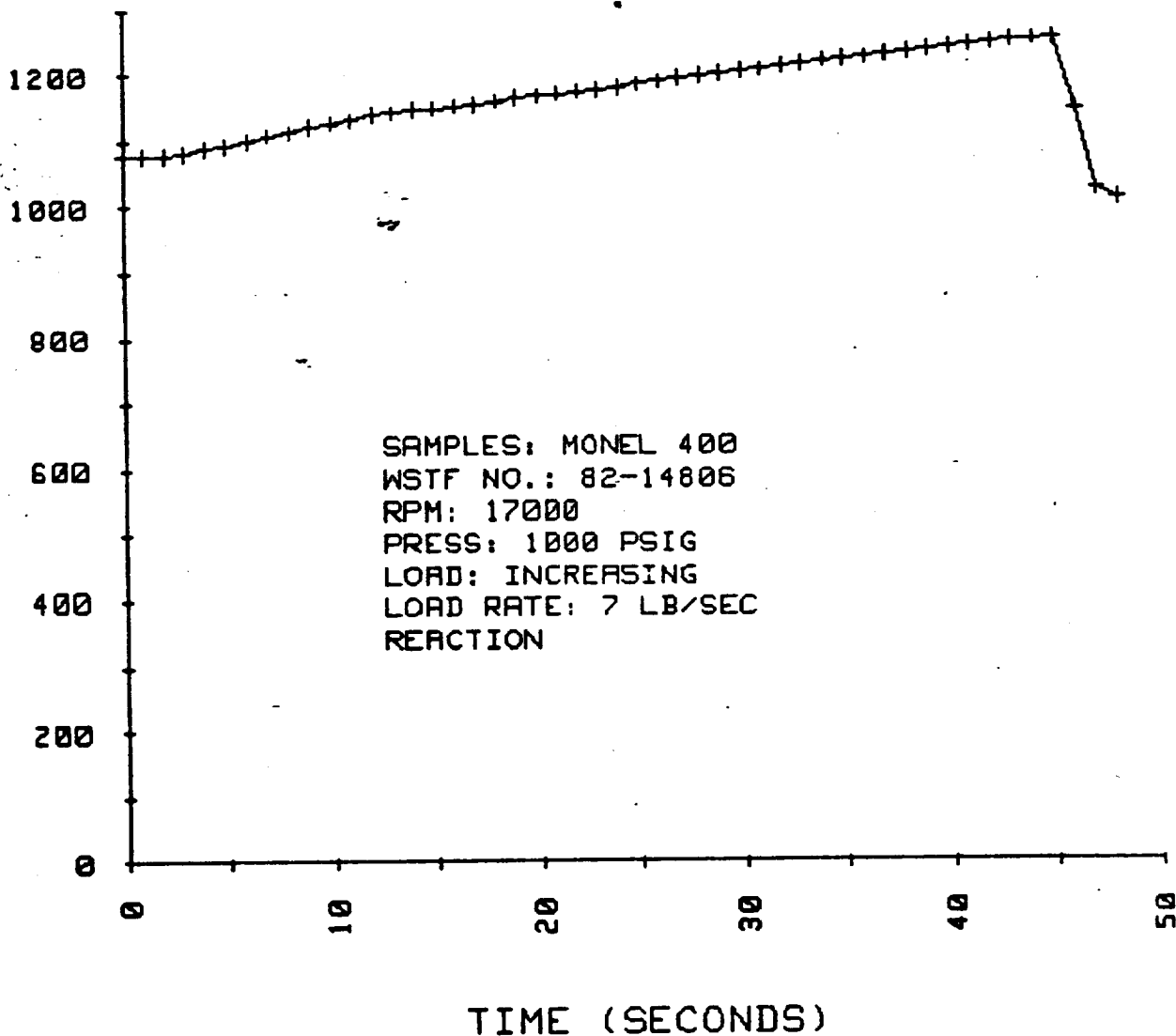


FRT #162 TEST #2 6/27/83



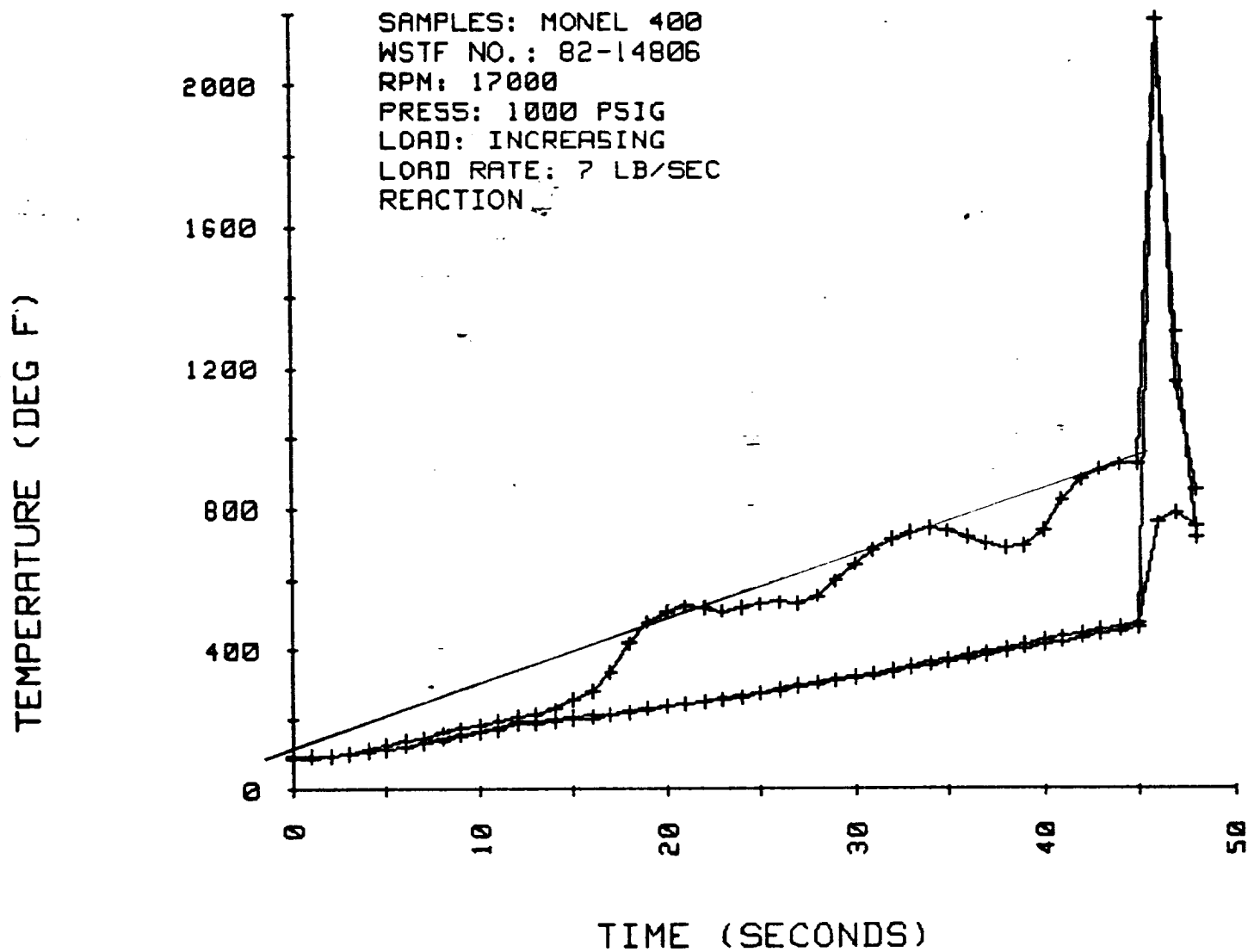
FRT #162 TEST #2 6/27/83

CHAMBER PRESSURE (PSIG)



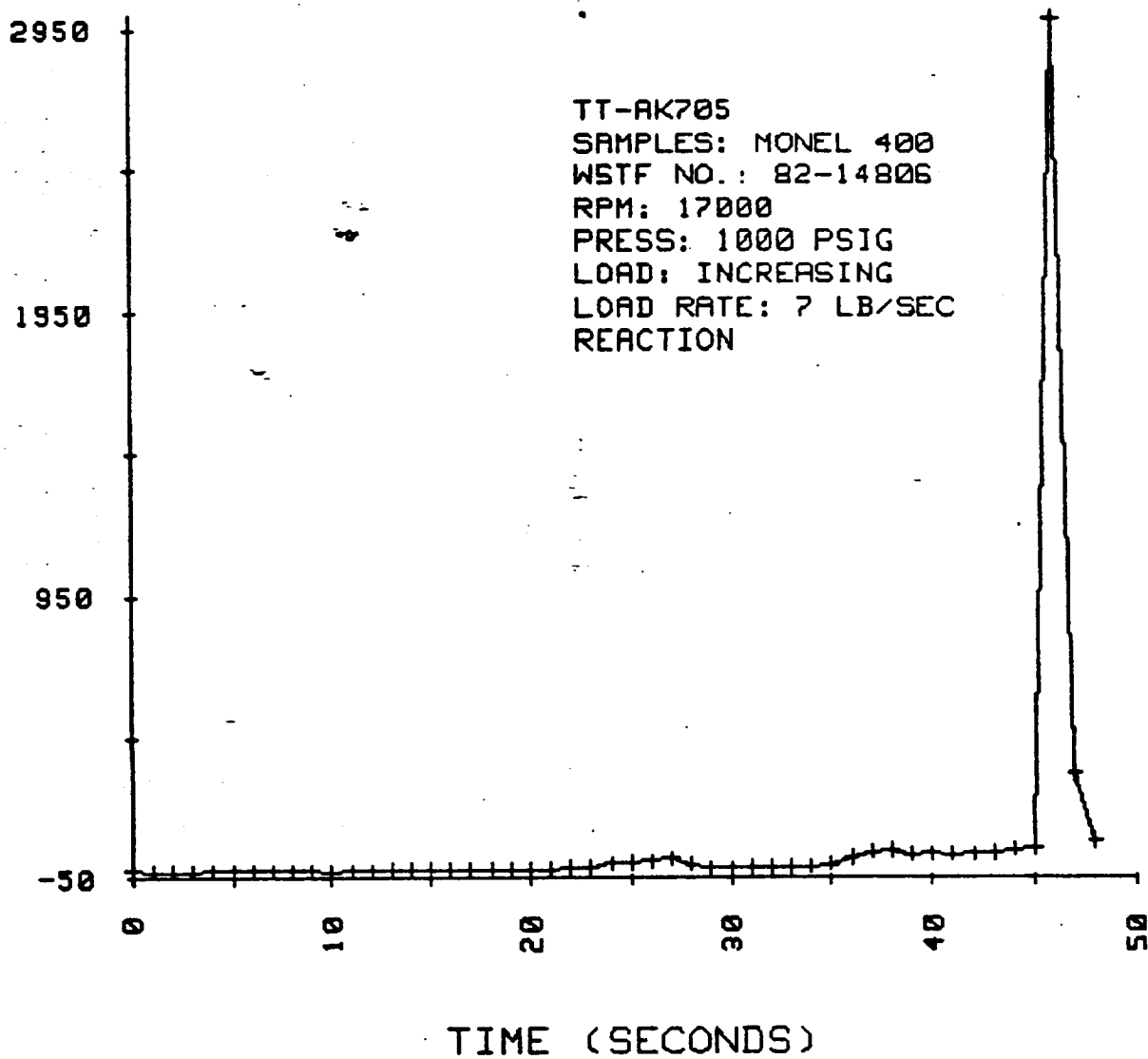
FRT #162 TEST #2 6/27/83

SAMPLES: MONEL 400
WSTF NO.: 82-14806
RPM: 17000
PRESS: 1000 PSIG
LOAD: INCREASING
LOAD RATE: 7 LB/SEC
REACTION



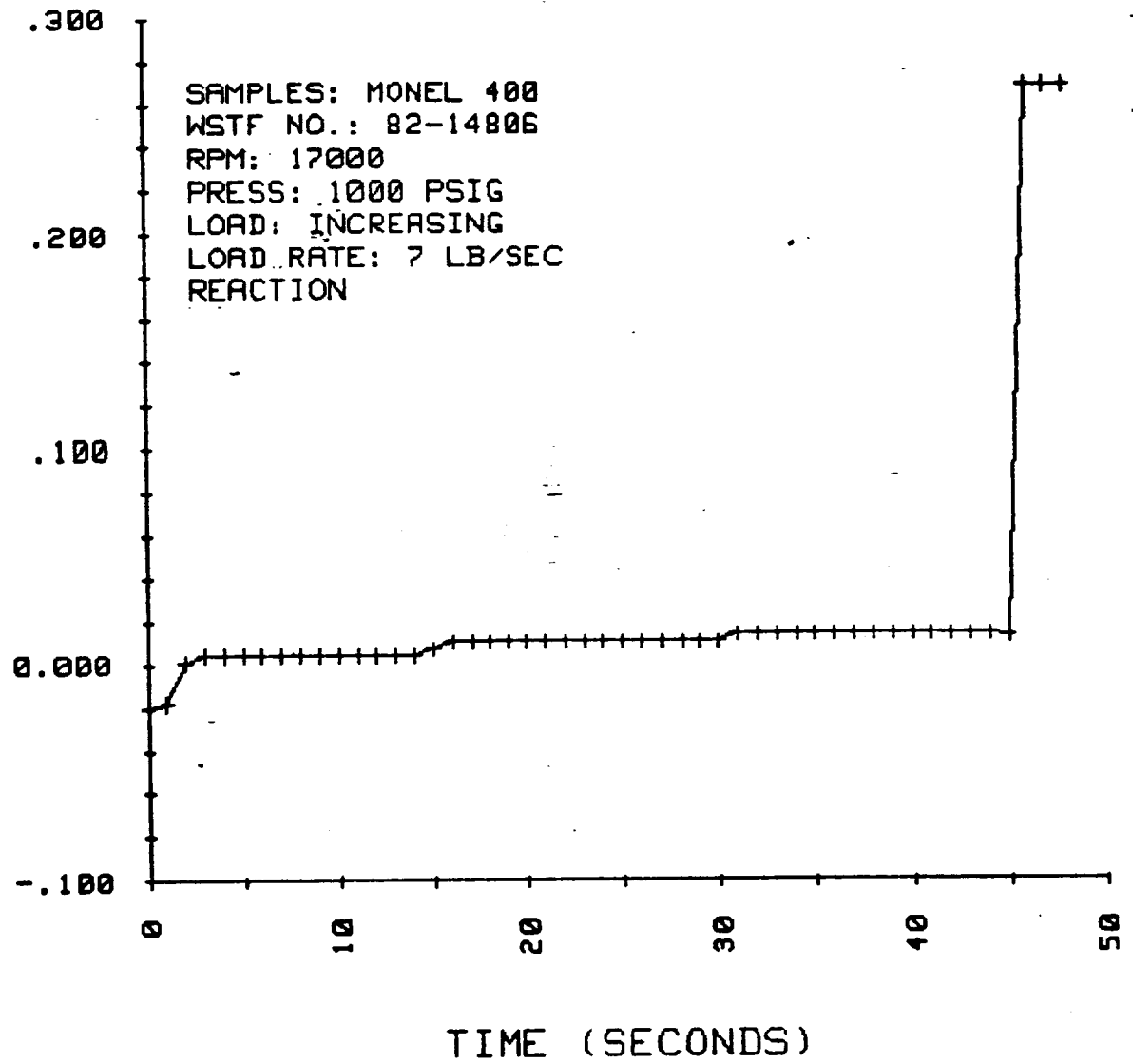
FRT #162 TEST #2 6/27/83

THERMOPILE OUTPUT (1/100MV)



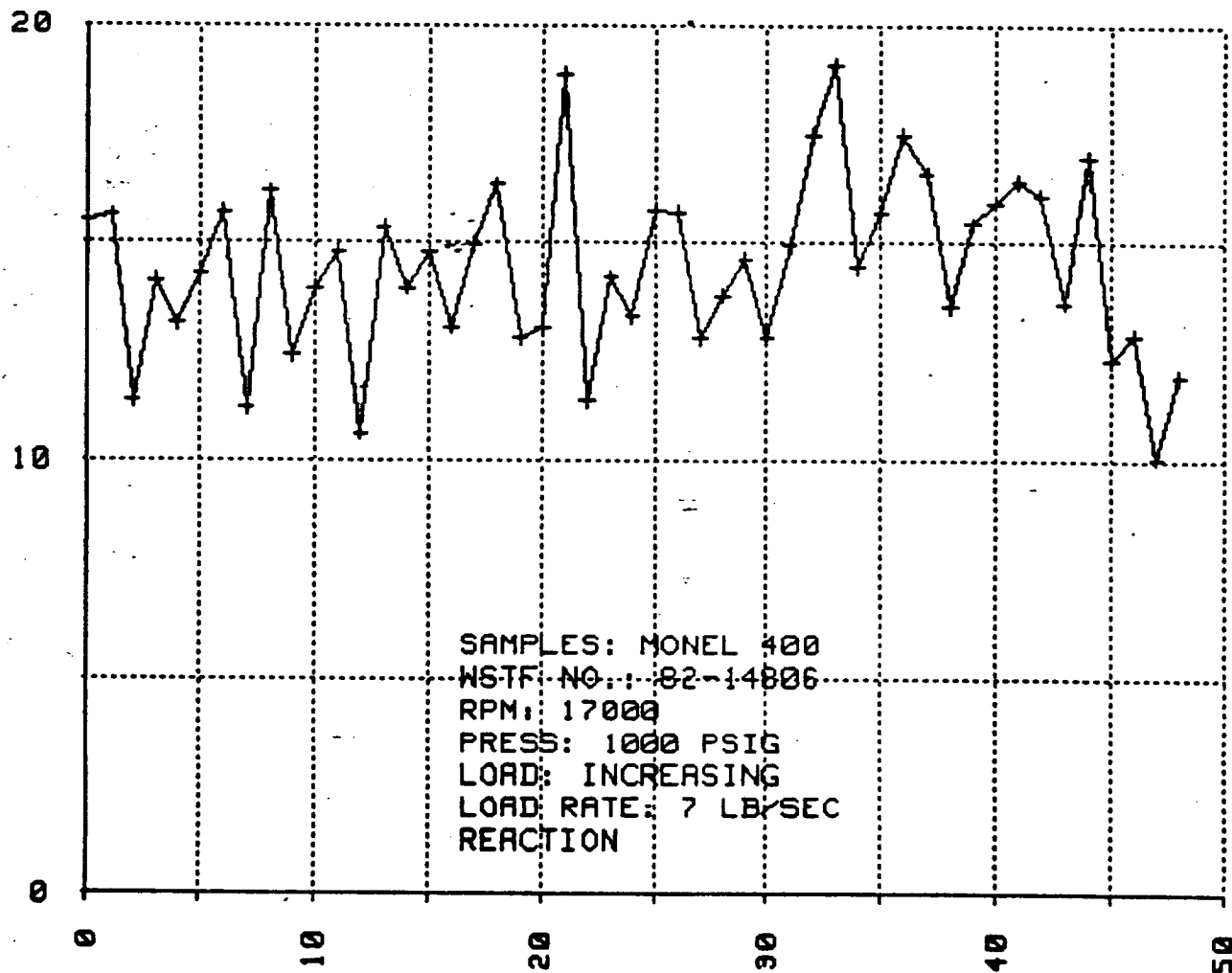
FRT #162 TEST #2 6/27/83

SAMPLE DISPLACEMENT (INCHES)



FRT #162 TEST #2 6/27/83

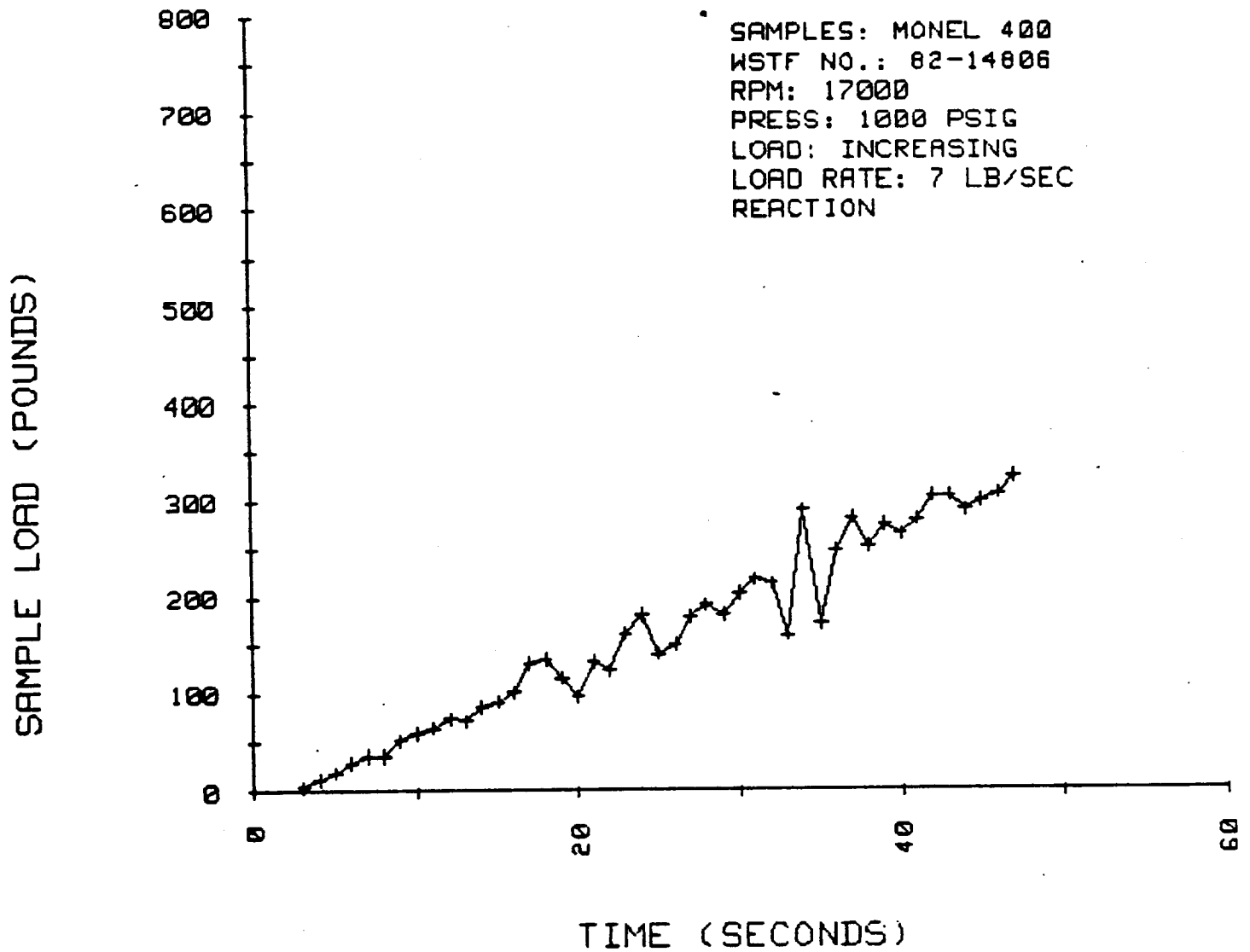
CHAMBER TORQUE LOAD (POUNDS)



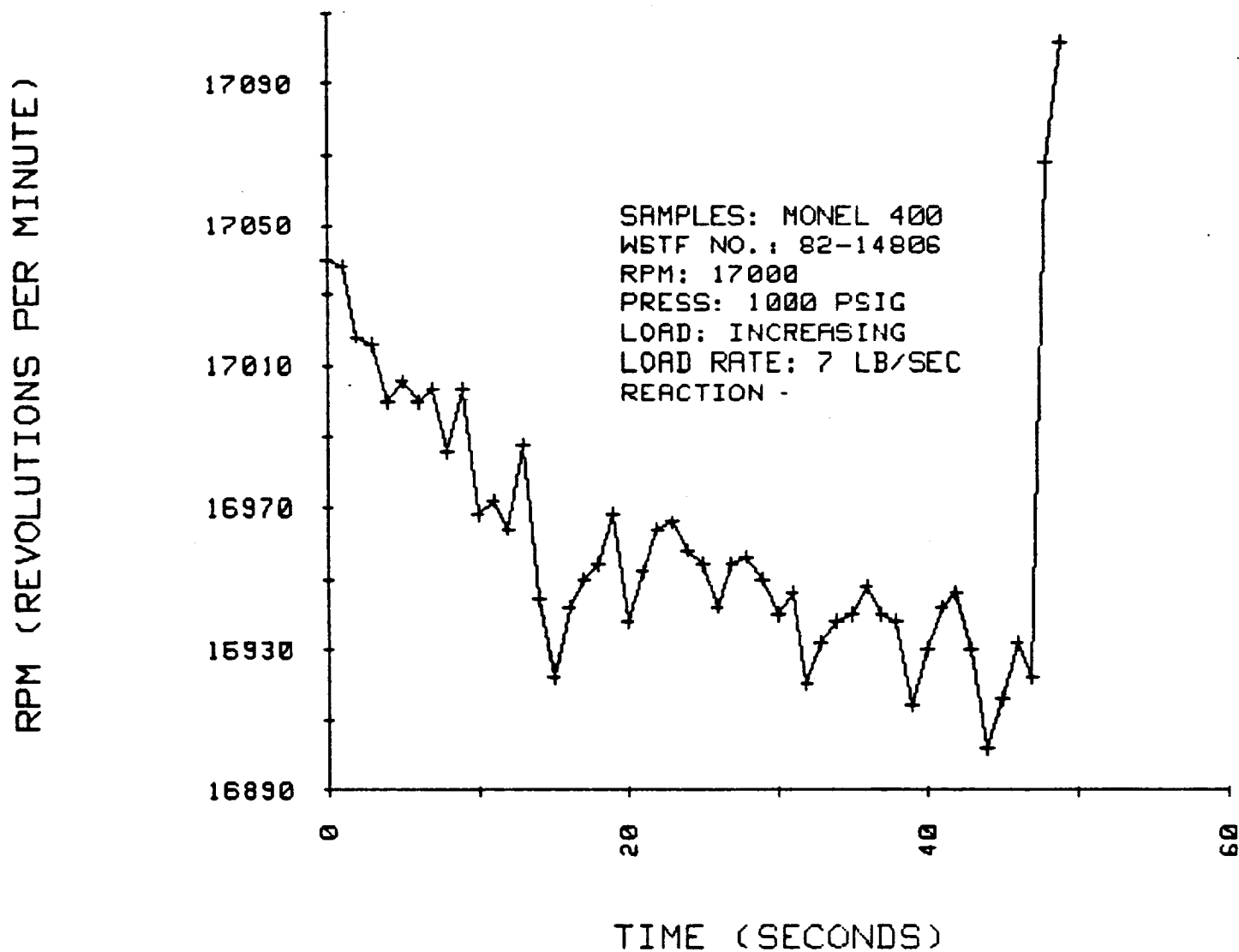
TIME (SECONDS)

FRT #163 TEST #3 6/27/83

SAMPLES: MONEL 400
WSTF NO.: 82-14806
RPM: 17000
PRESS: 1000 PSIG
LOAD: INCREASING
LOAD RATE: 7 LB/SEC
REACTION

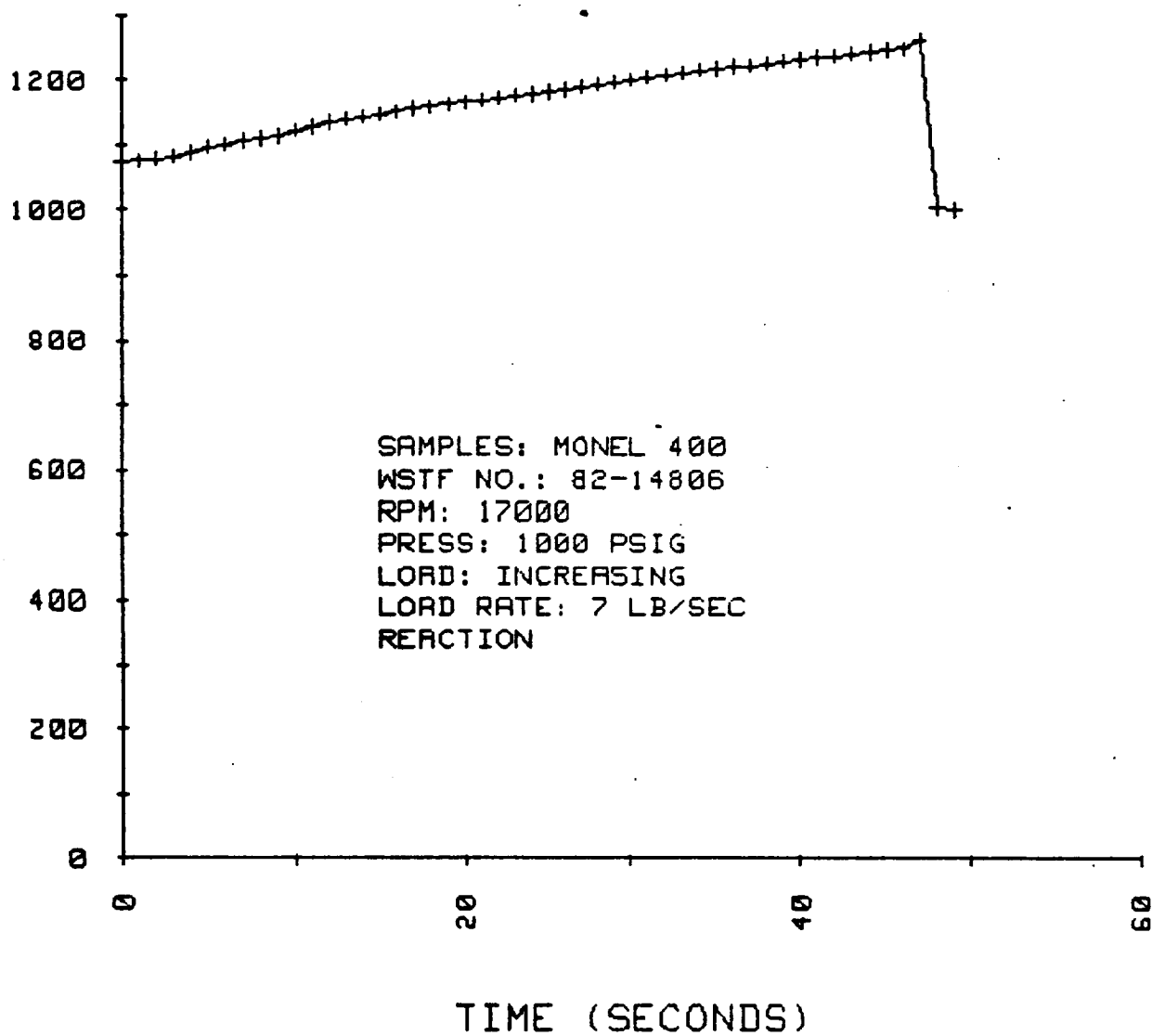


FRT #163 TEST #3 6/27/83

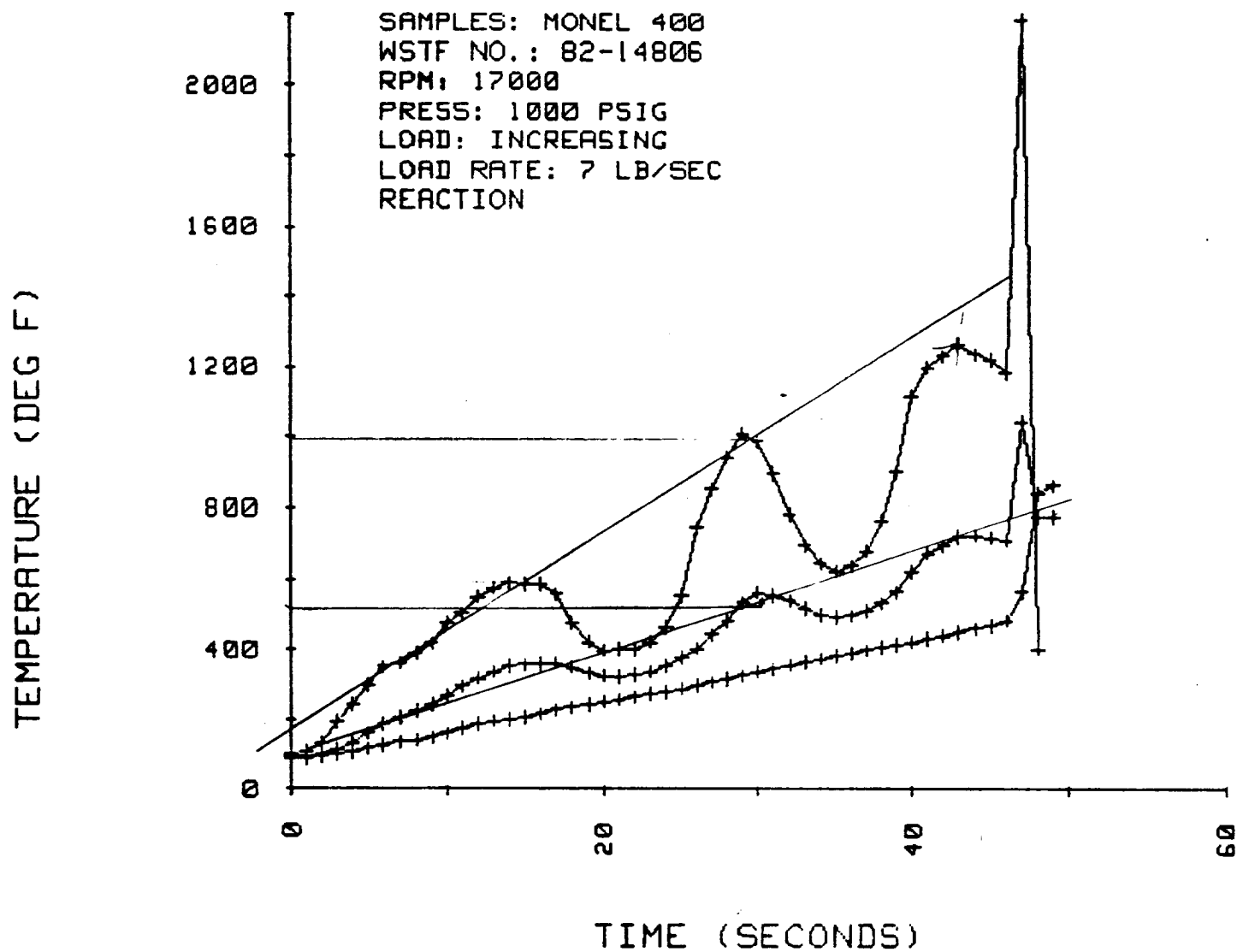


CHAMBER PRESSURE (PSIG)

FRT #163 TEST #3 6/27/83

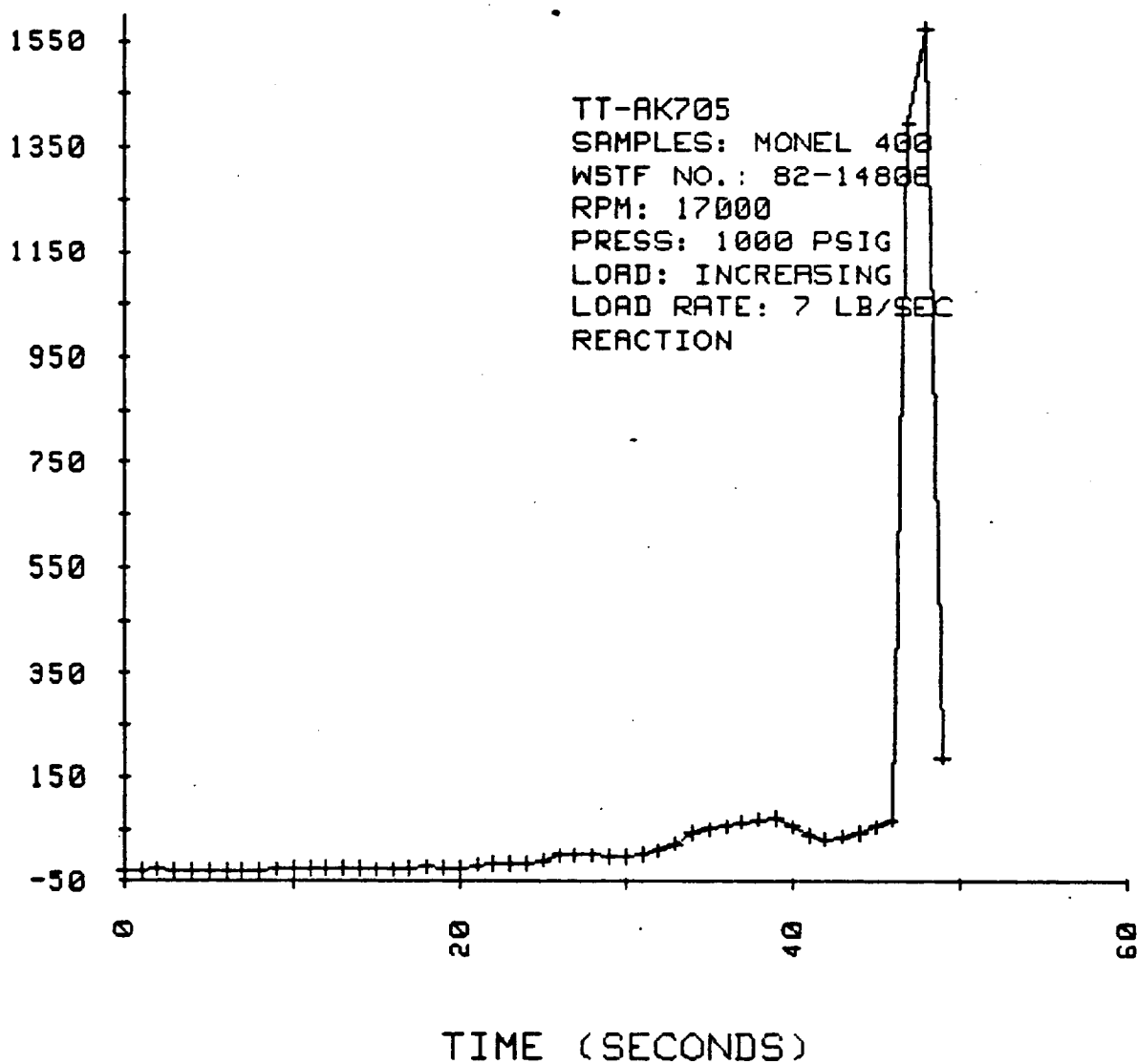


FRT #163 TEST #3 6/27/83



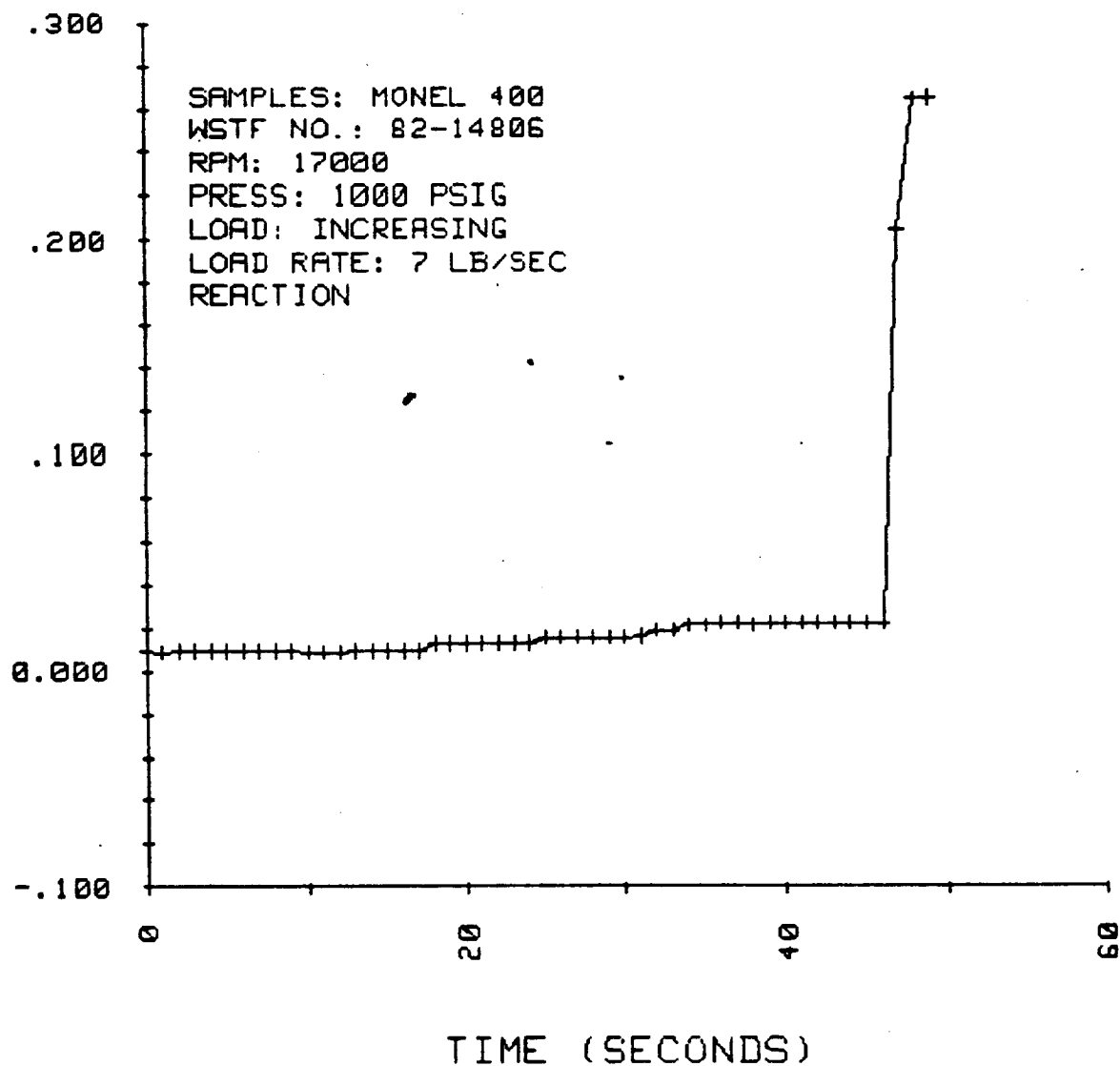
FRT #163 TEST #3 6/27/83

THERMOPILE OUTPUT (1/100MV)

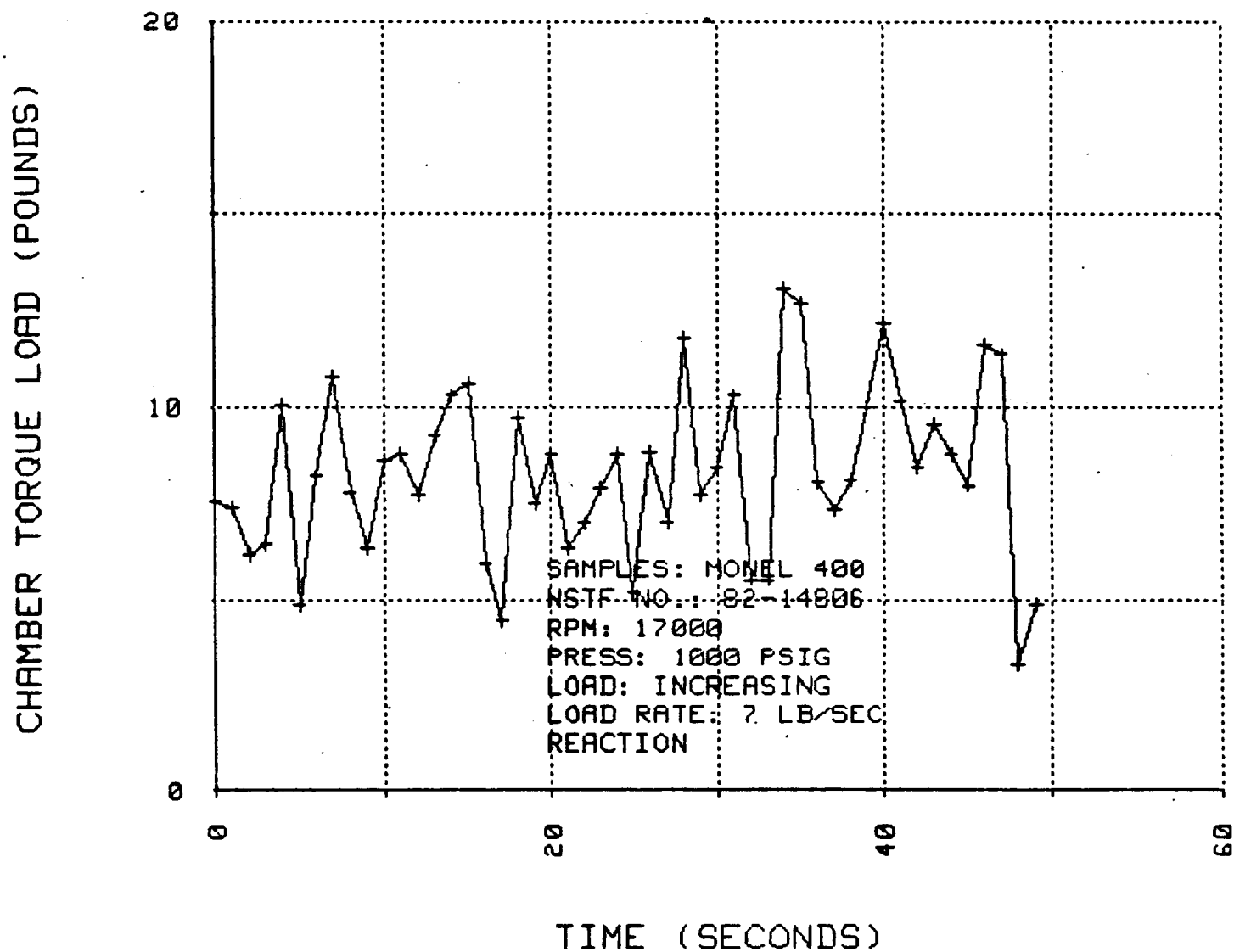


SAMPLE DISPLACEMENT (INCHES)

FRT #163 TEST #3 6/27/83

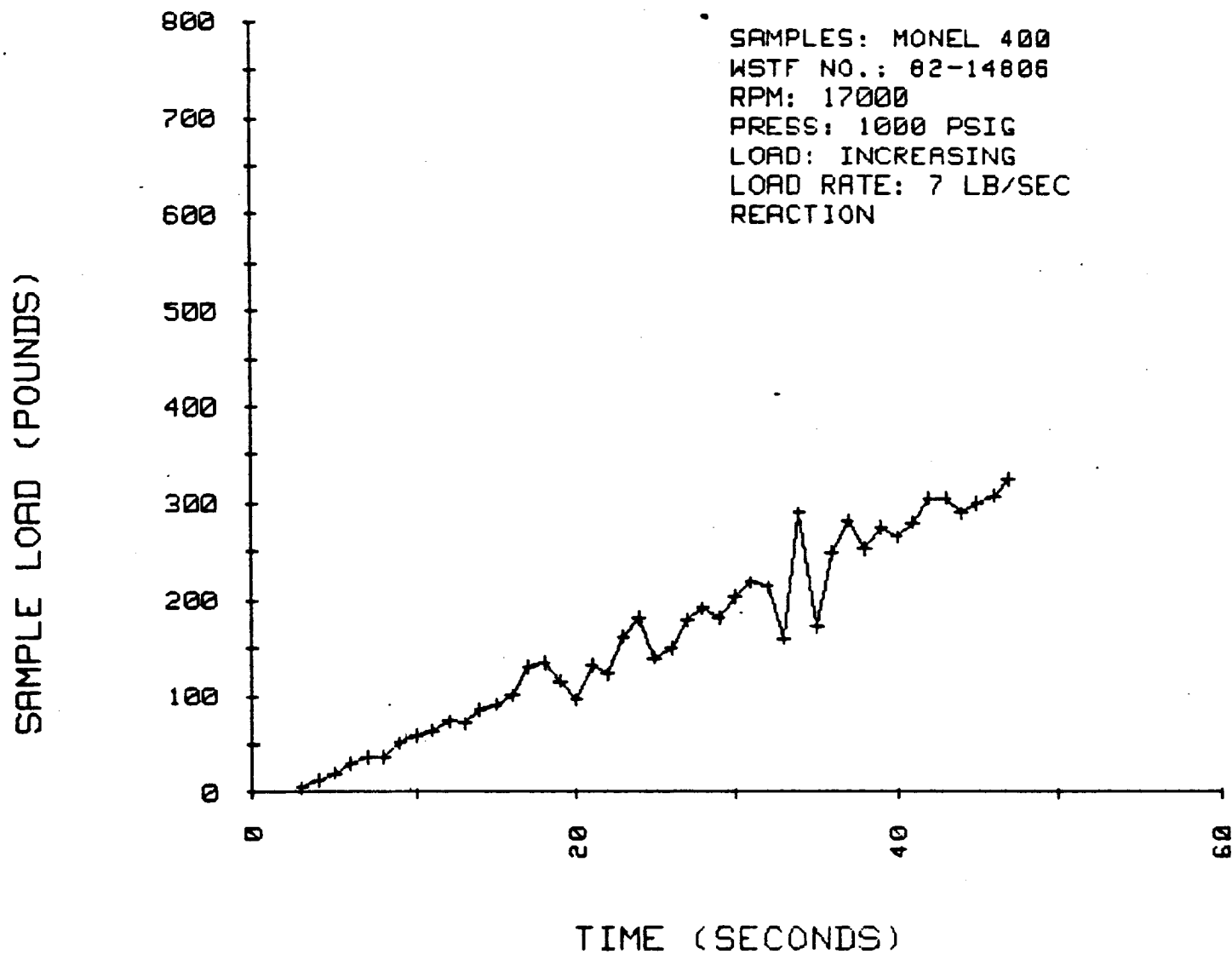


FRT #163 TEST #3 6/27/83

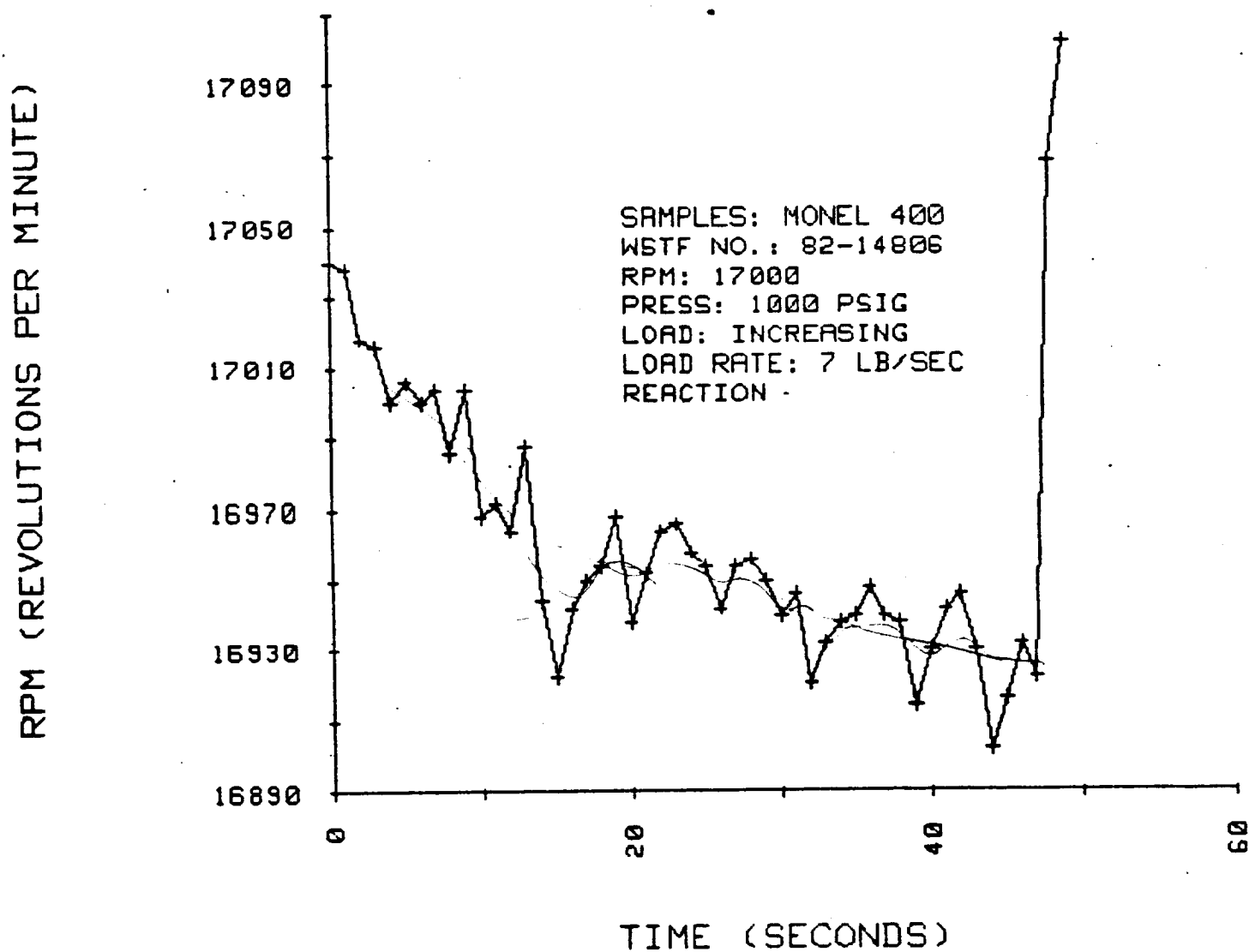


FRT #163 TEST #3 6/27/83

SAMPLES: MONEL 400
WSTF NO.: 82-14806
RPM: 17000
PRESS: 1000 PSIG
LOAD: INCREASING
LOAD RATE: 7 LB/SEC
REACTION

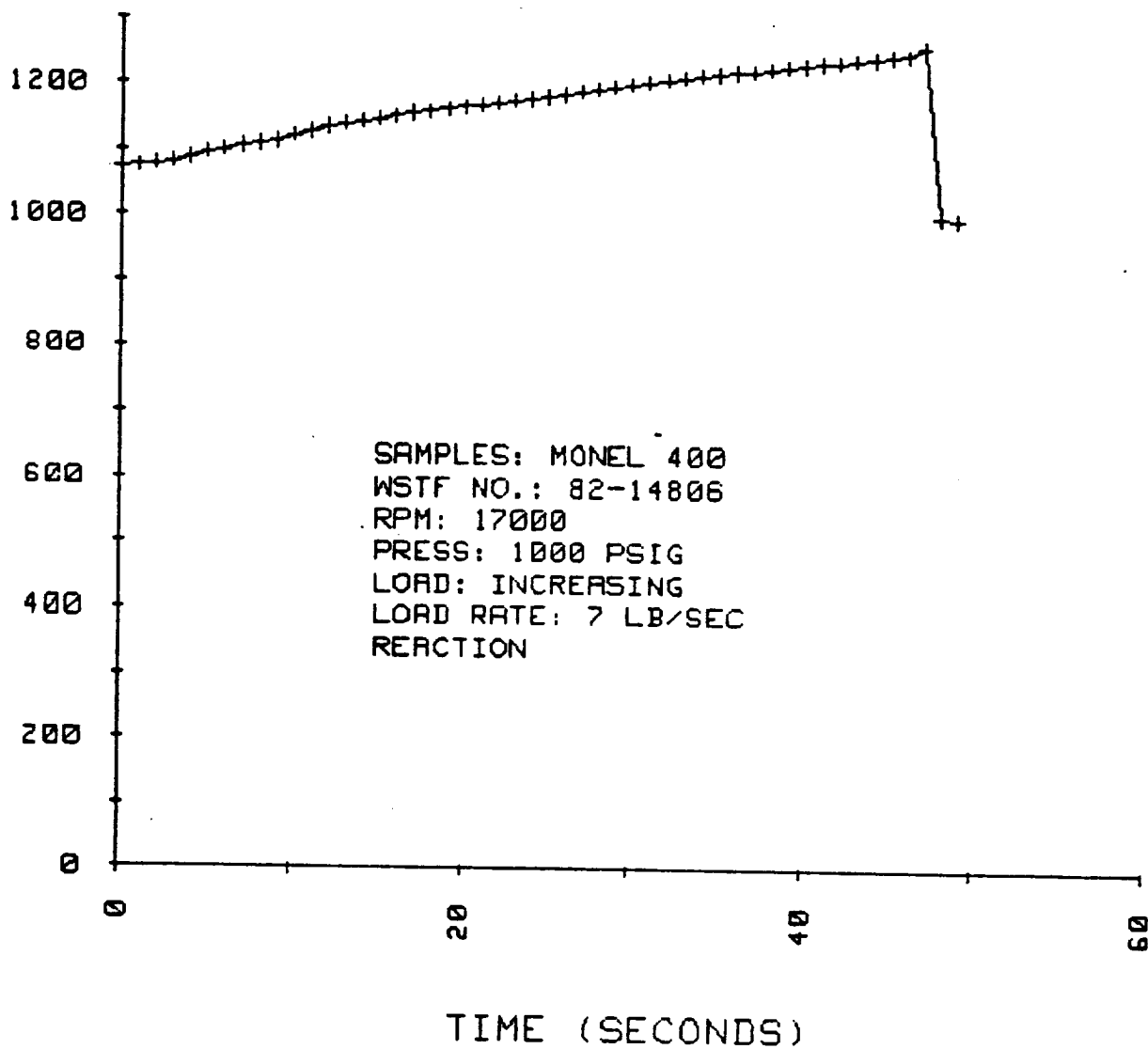


FRT #163 TEST #3 6/27/83



FRT #163 TEST #3 6/27/83

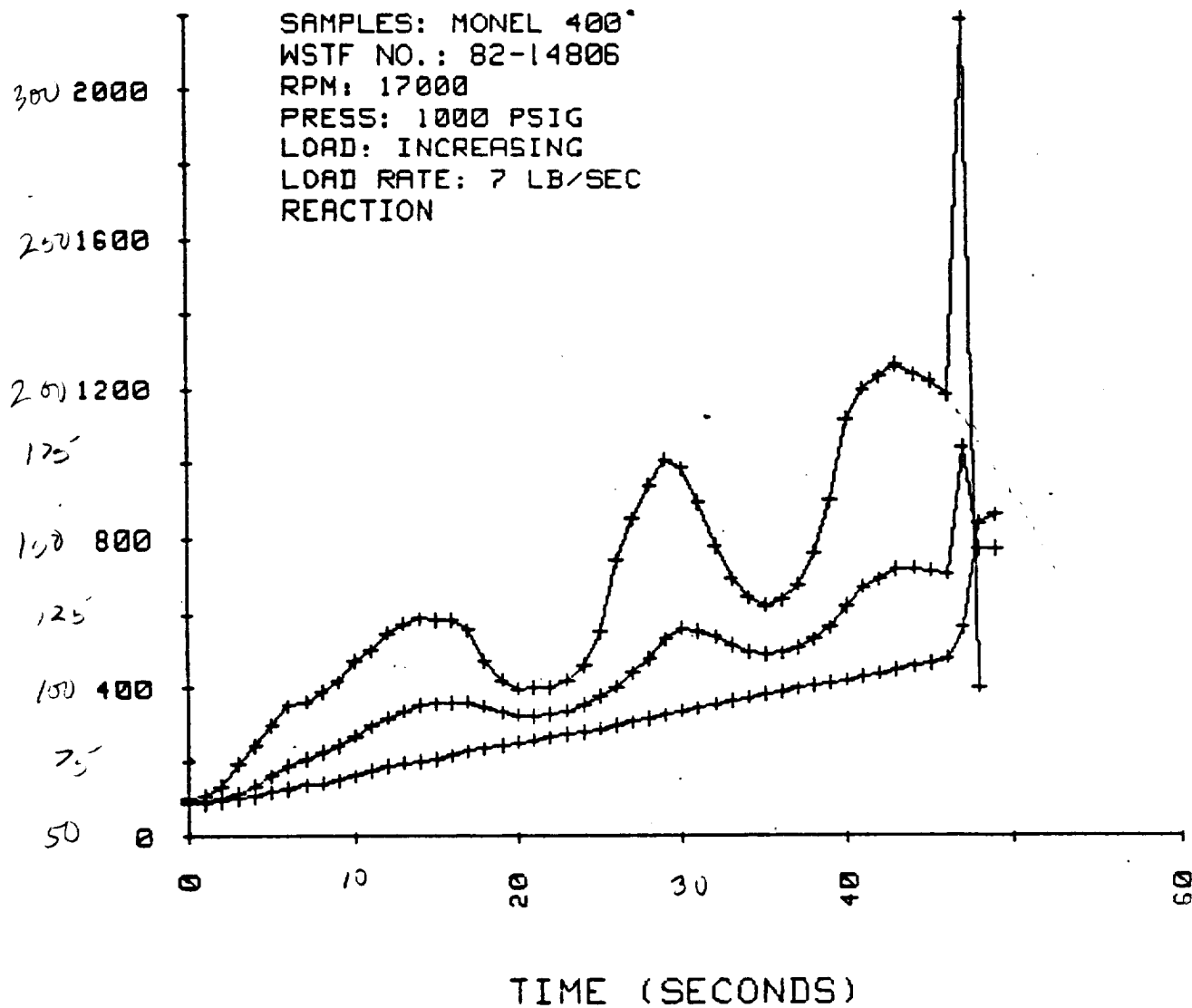
CHAMBER PRESSURE (PSIG)



FRT #163 TEST #3 6/27/83

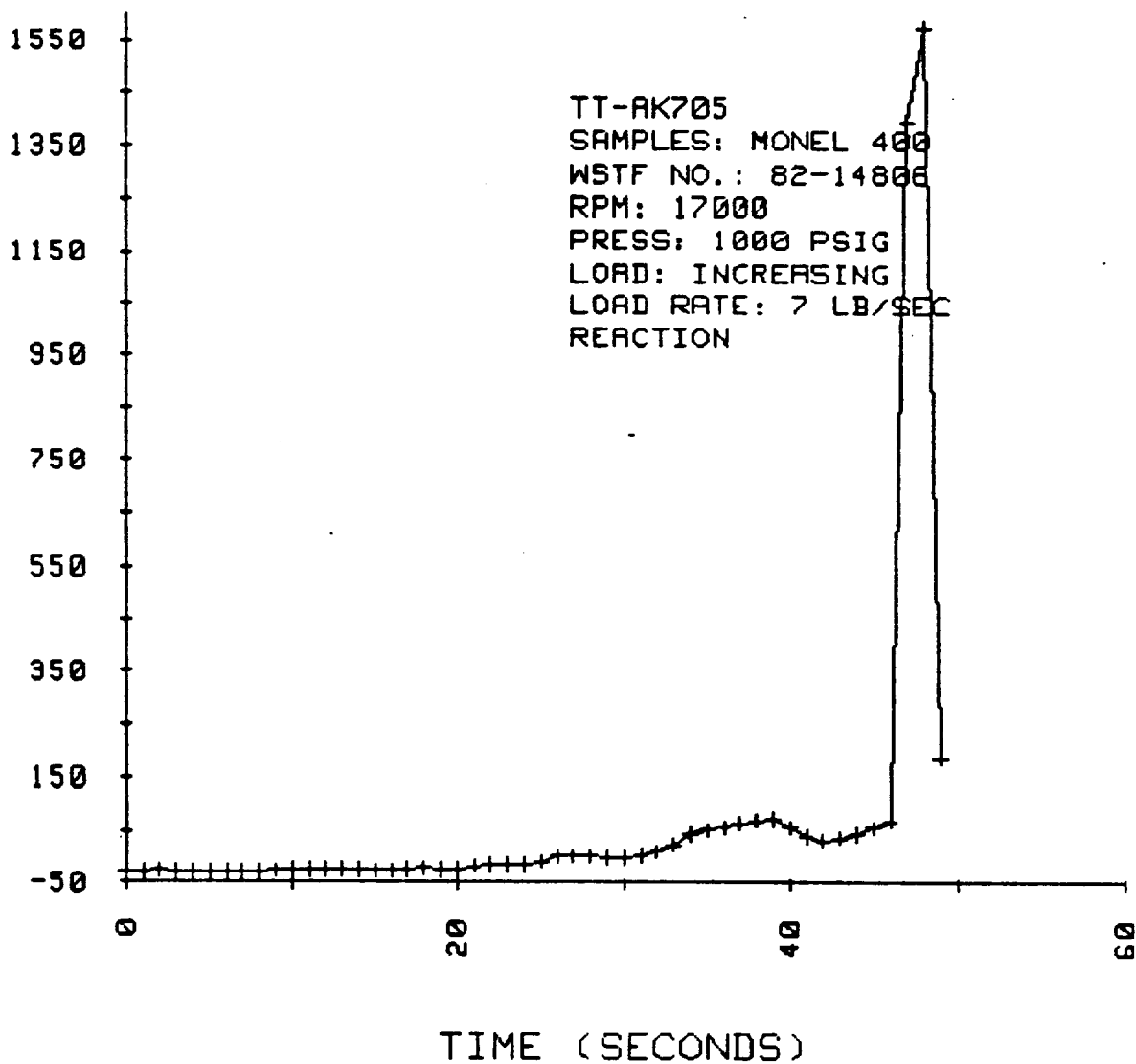
SAMPLES: MONEL 400⁺
 WSTF NO.: 82-14806
 RPM: 17000
 PRESS: 1000 PSIG
 LOAD: INCREASING
 LOAD RATE: 7 LB/SEC
 REACTION

TEMPERATURE (DEG F)



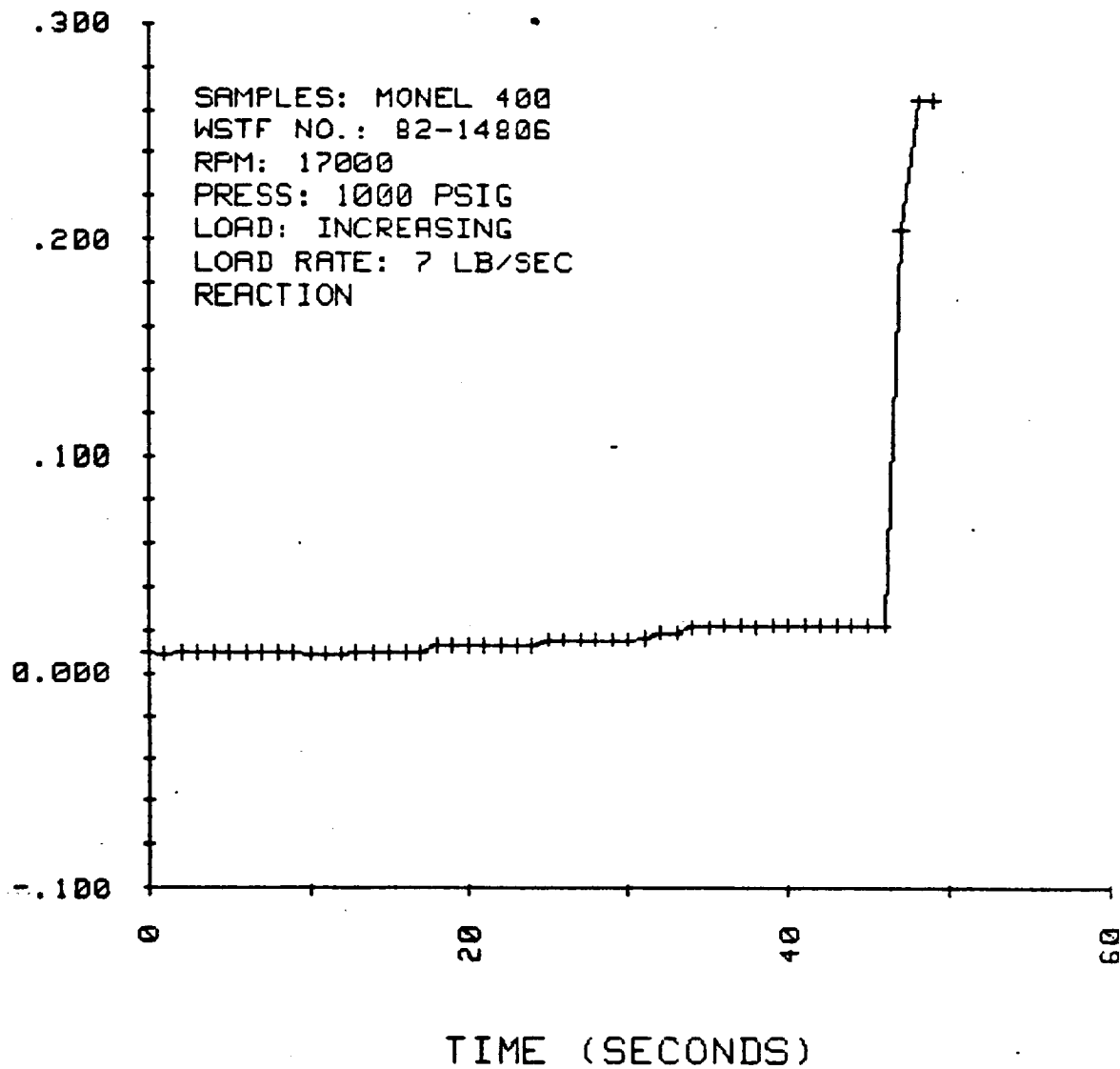
FRT #163 TEST #3 6/27/83

THERMOPILE OUTPUT (1/100MV)

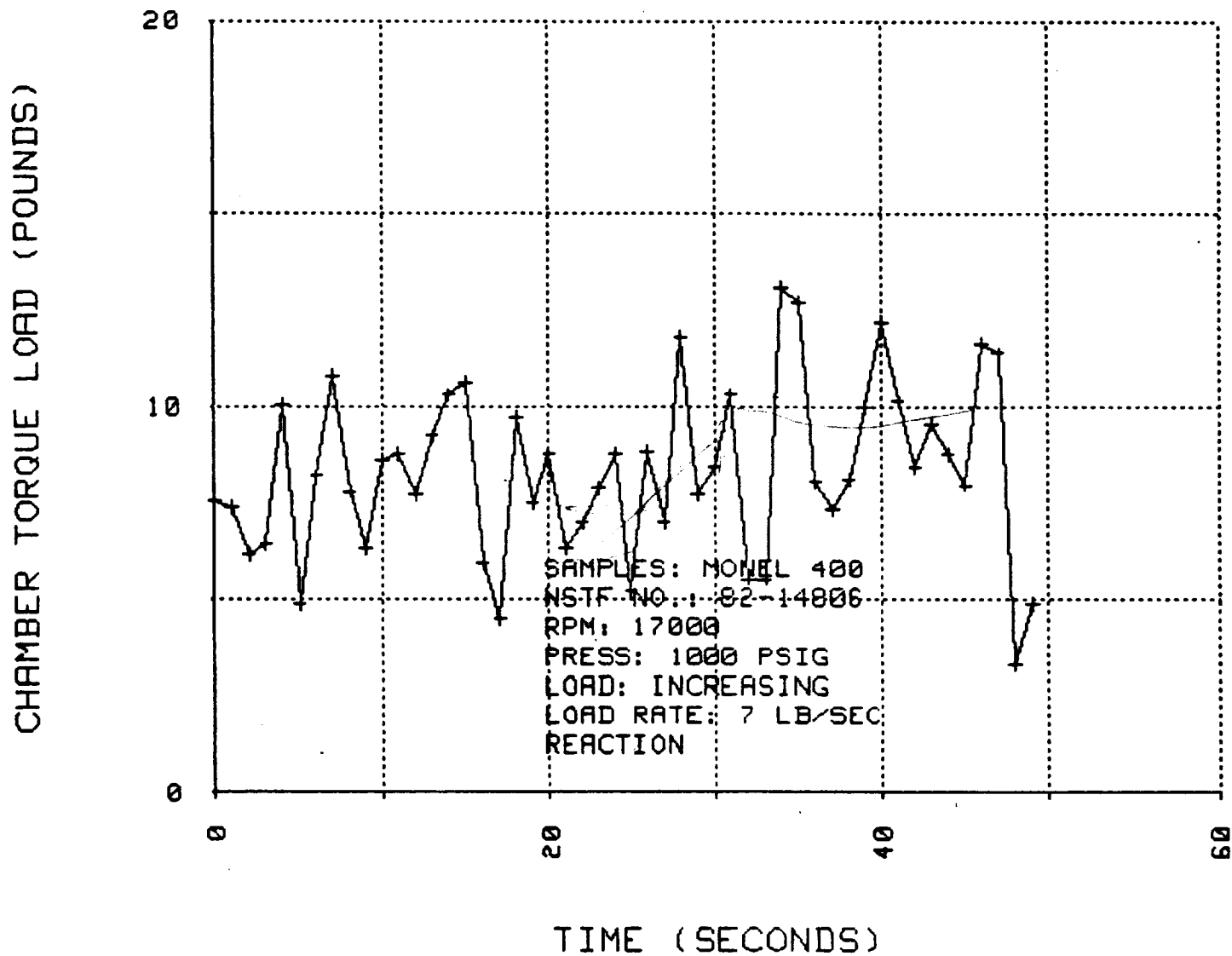


SAMPLE DISPLACEMENT (INCHES)

FRT #163 TEST #3 6/27/83

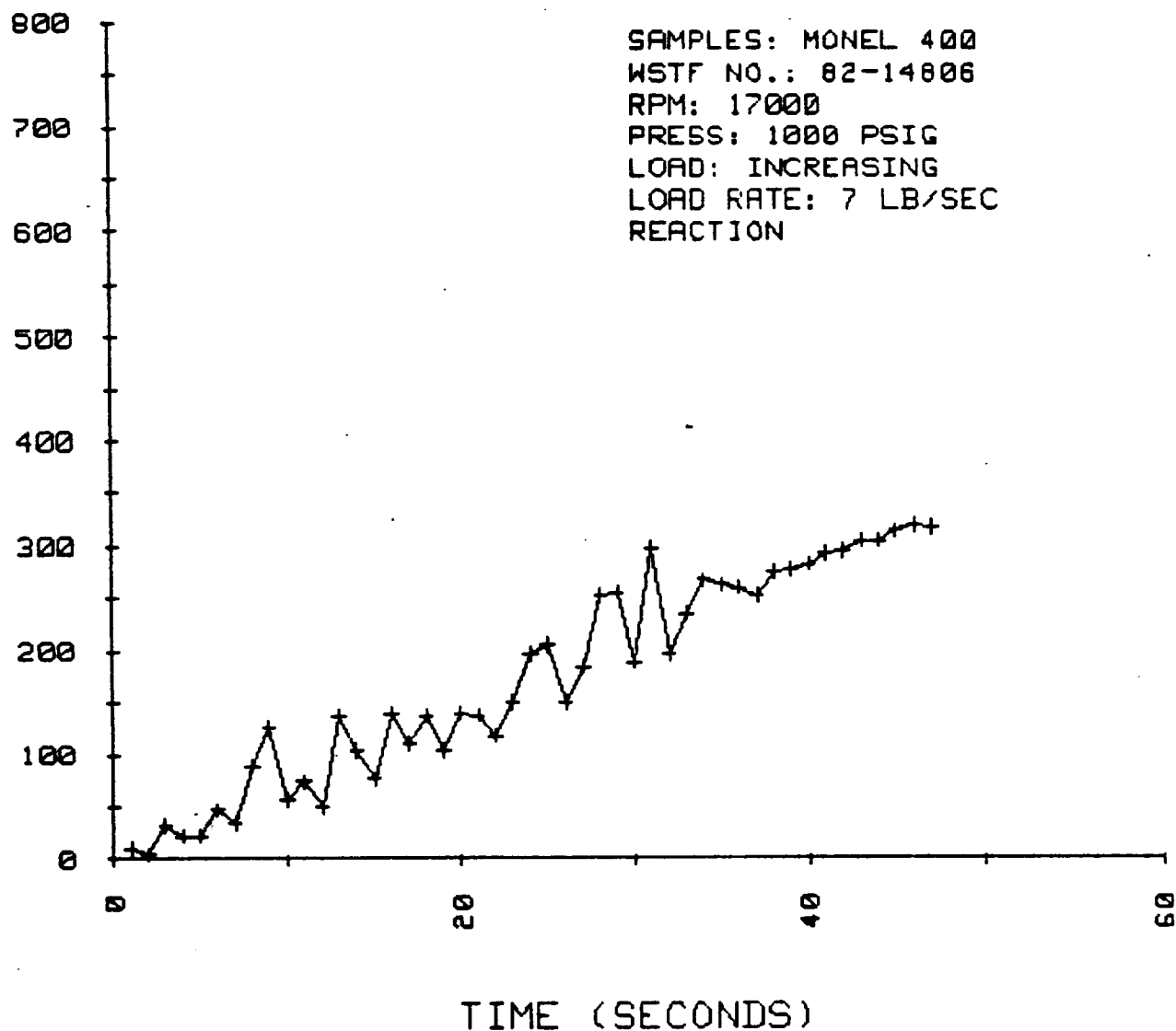


FRT #163 TEST #3 6/27/83



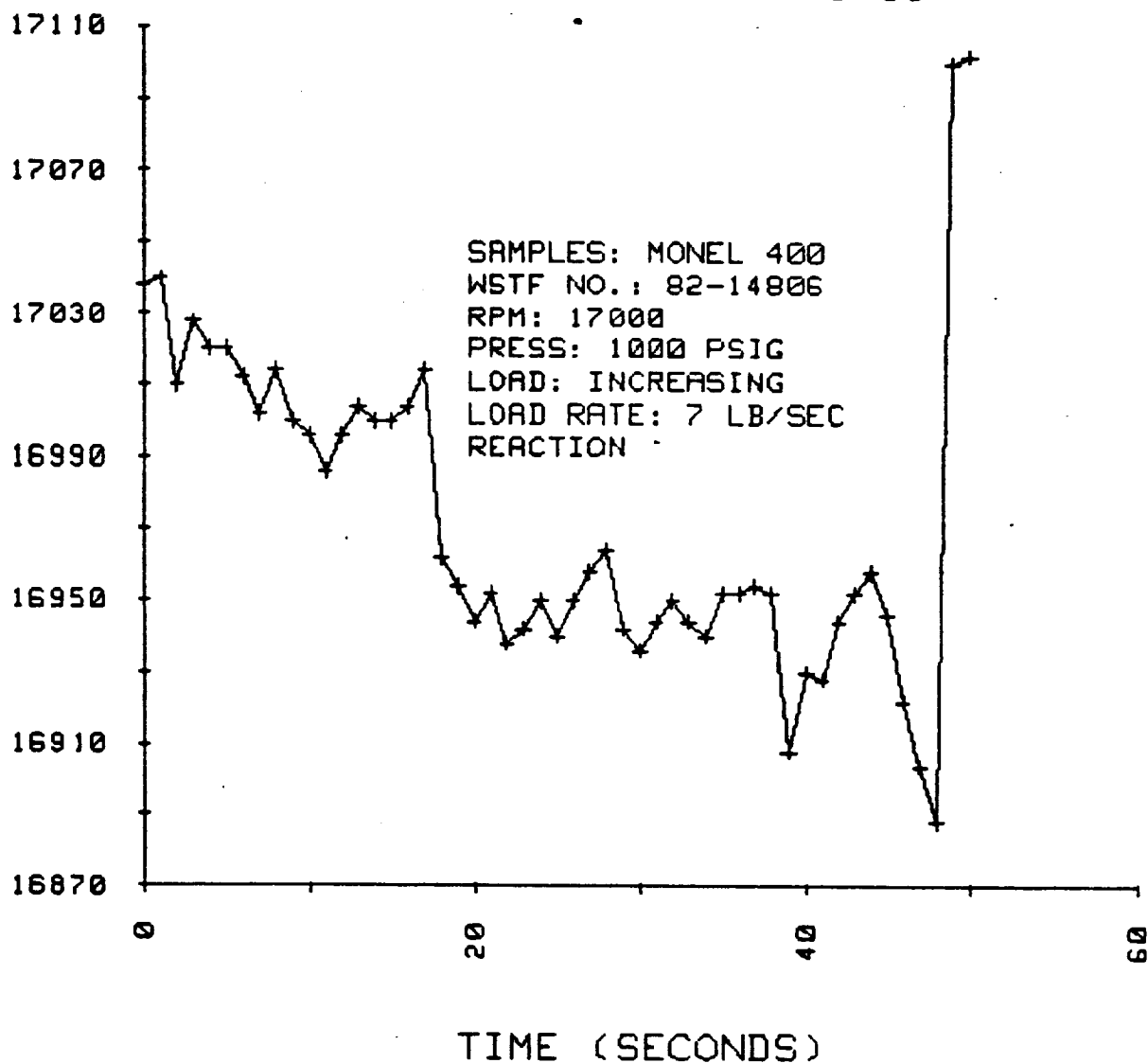
FRT #164 TEST #1 6/28/83

SAMPLE LOAD (POUNDS)



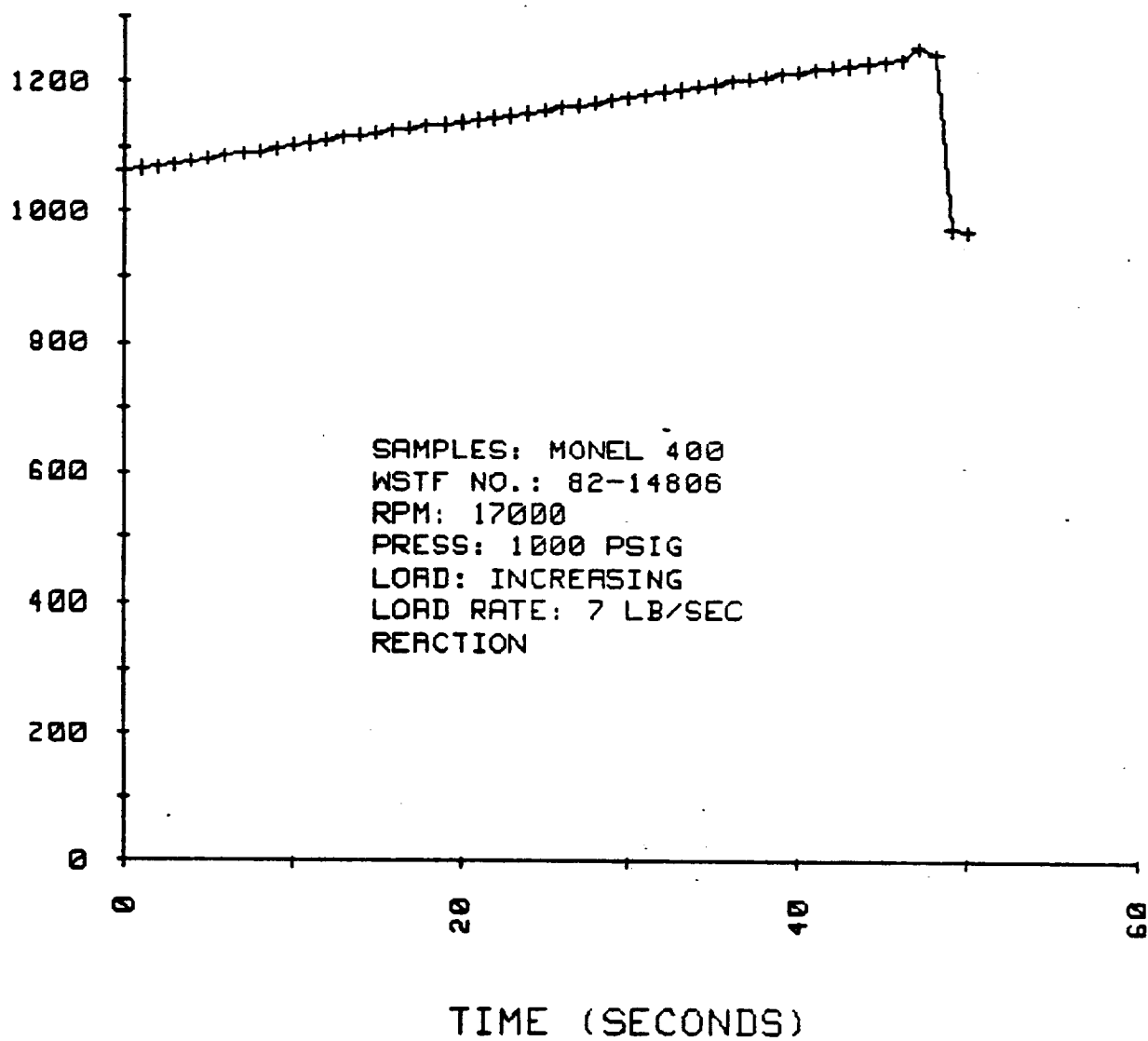
RPM (REVOLUTIONS PER MINUTE)

FRT #164 TEST #1 6/28/83



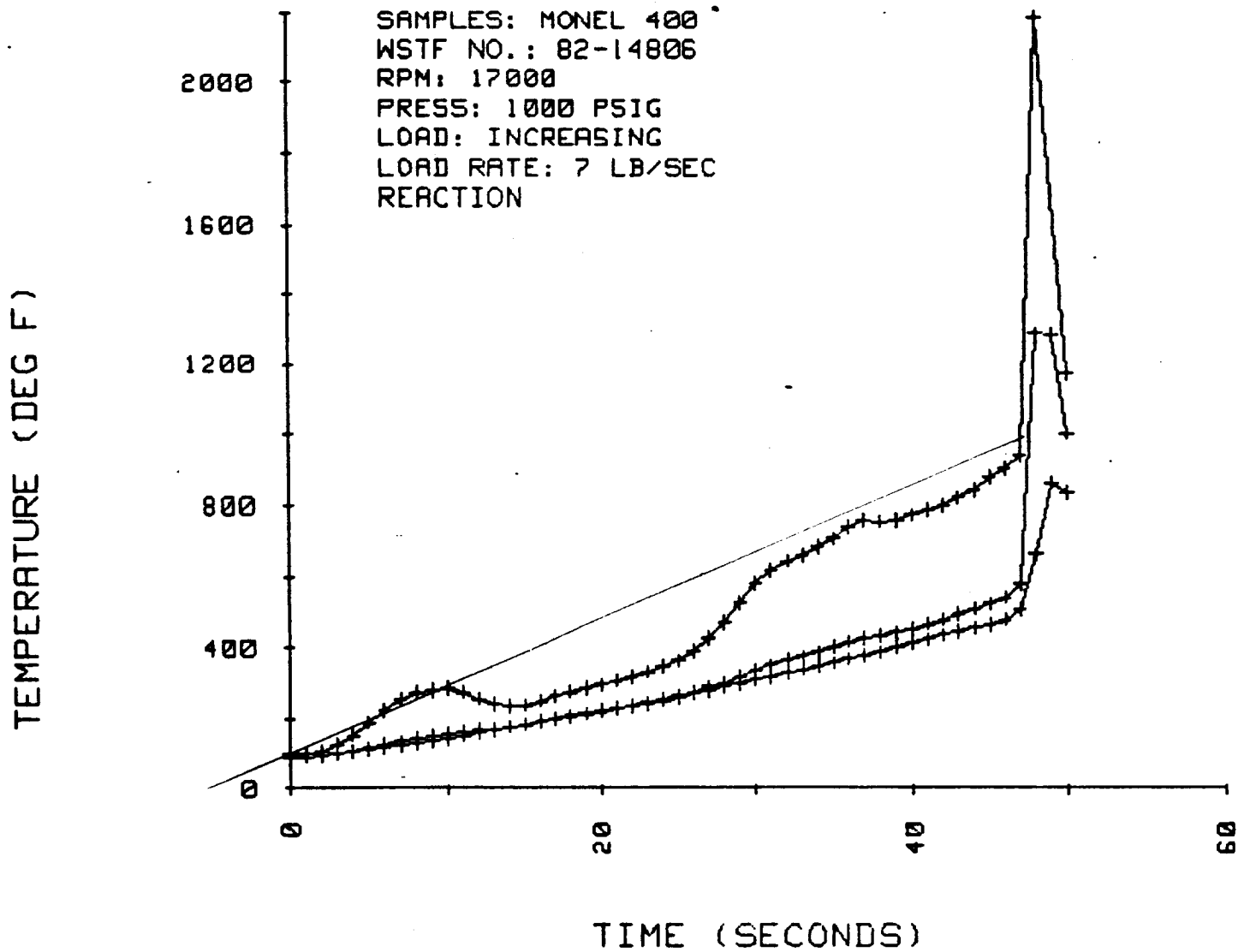
FRT #164 TEST #1 6/28/83

CHAMBER PRESSURE (PSIG)



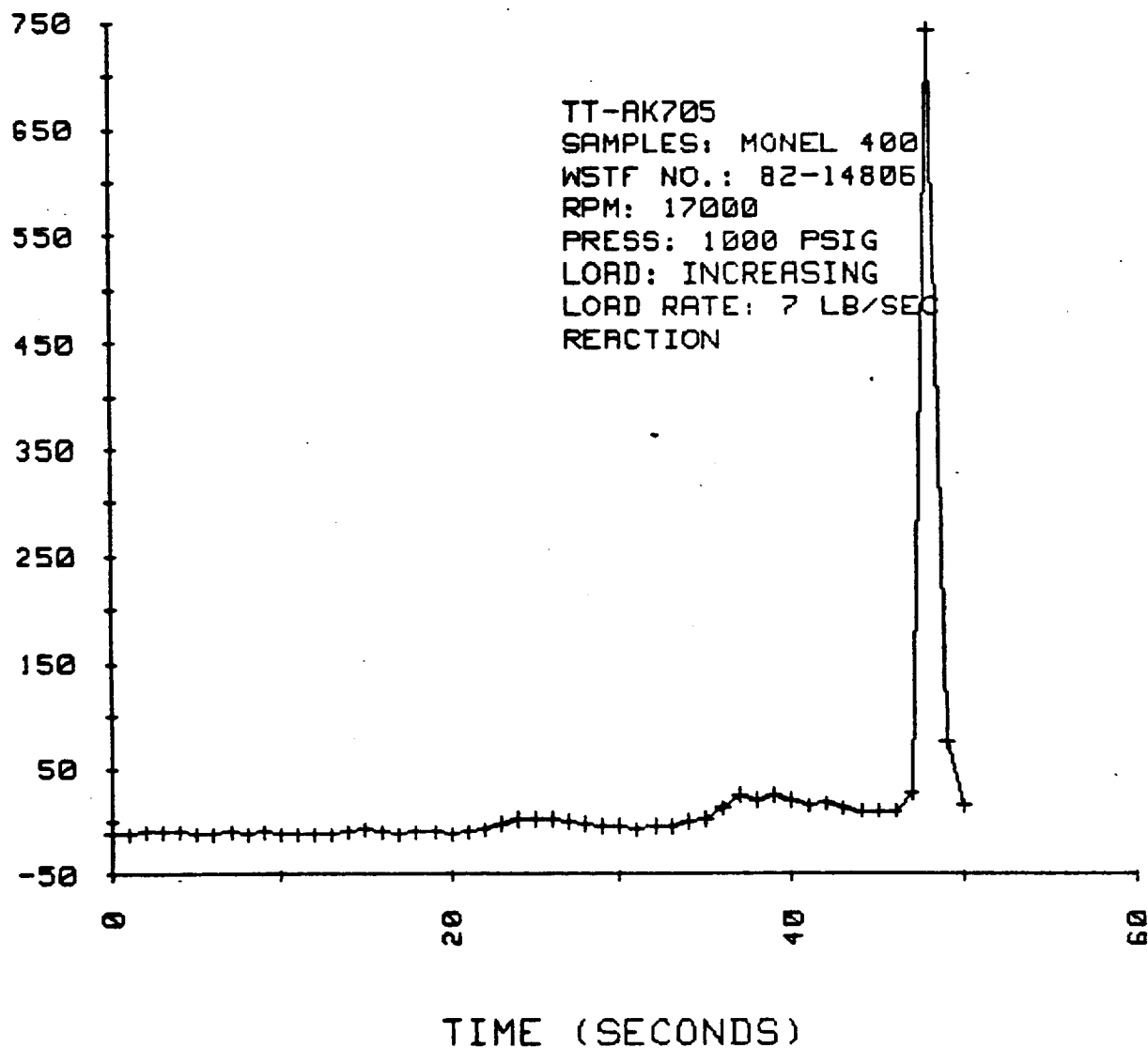
FRT #164 TEST #1 6/28/83

SAMPLES: MONEL 400
WSTF NO.: 82-14806
RPM: 17000
PRESS: 1000 PSIG
LOAD: INCREASING
LOAD RATE: 7 LB/SEC
REACTION



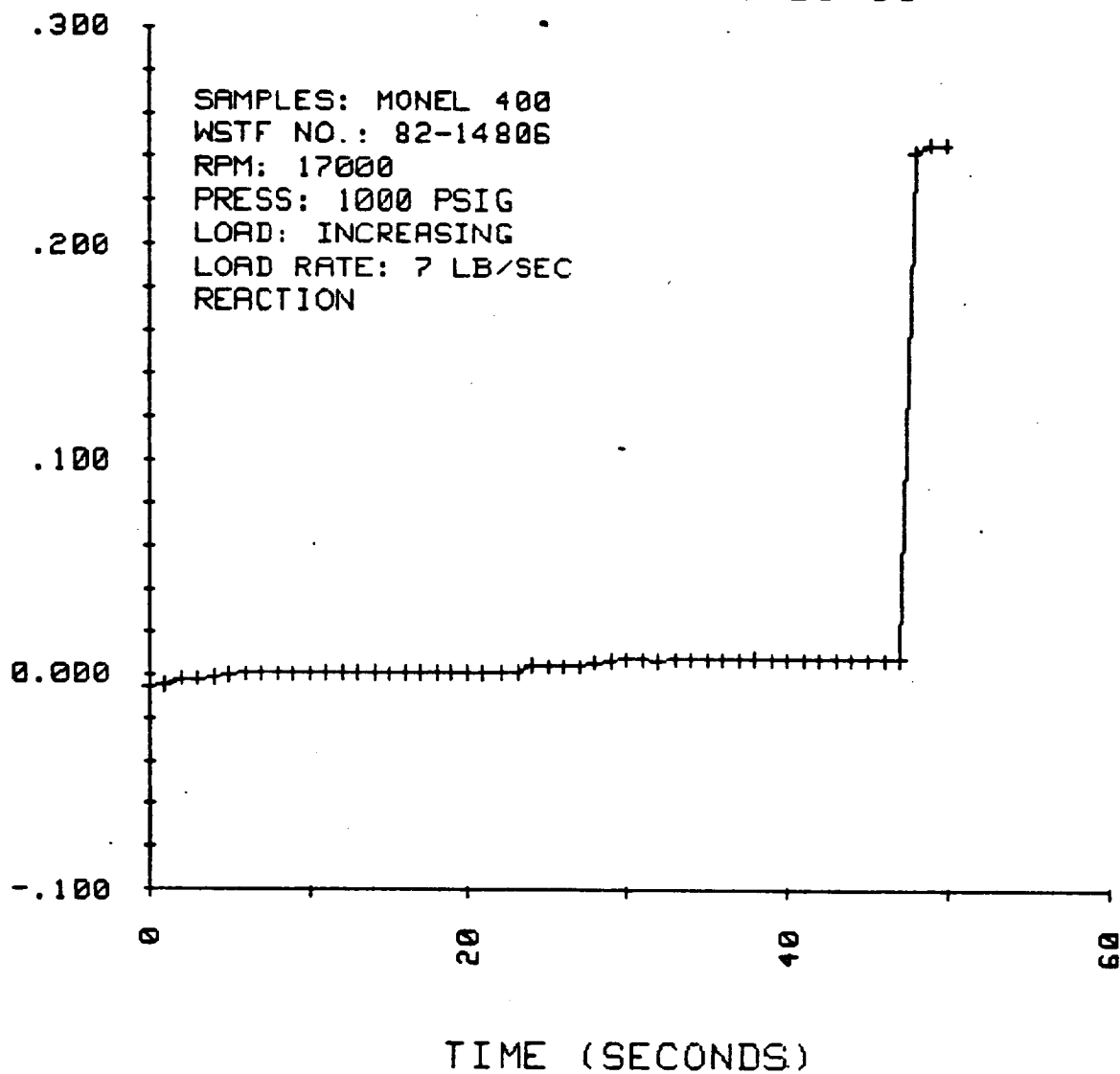
FRT #164 TEST #1 6/28/83

THERMOPILE OUTPUT (1/100MV)



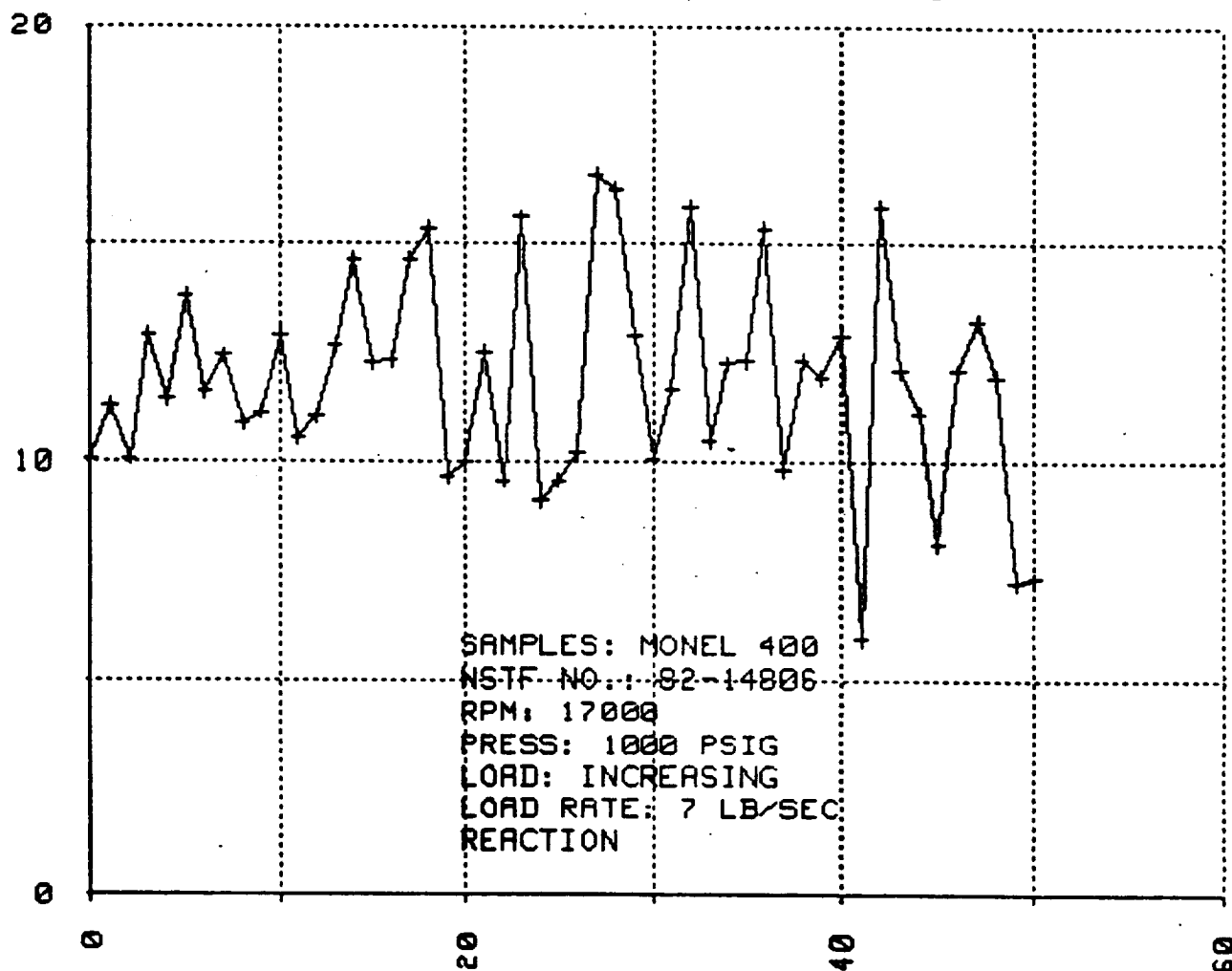
SAMPLE DISPLACEMENT (INCHES)

FRT #164 TEST #1 6/28/83



FRT #164 TEST #1 6/28/83

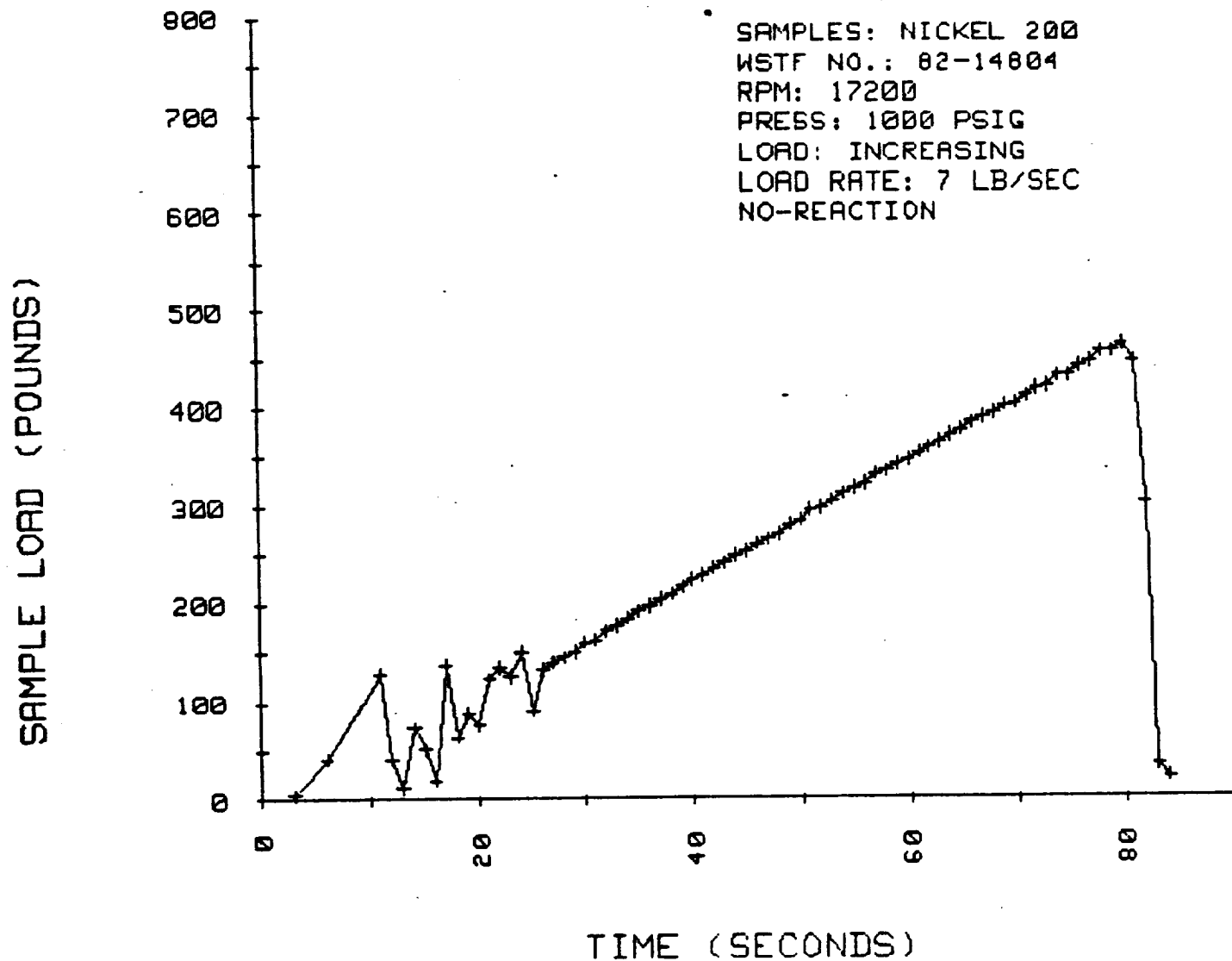
CHAMBER TORQUE LOAD (POUNDS)



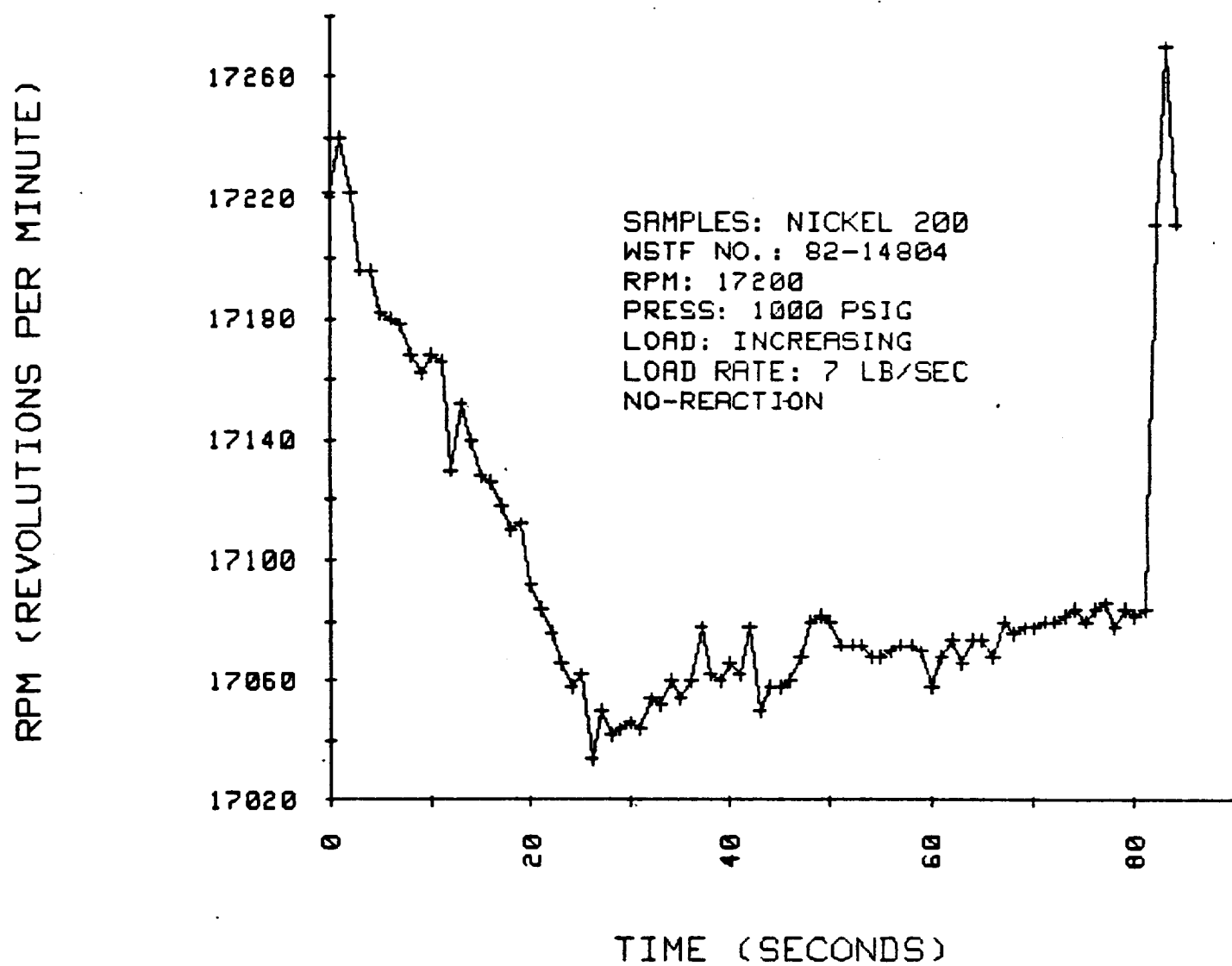
TIME (SECONDS)

FRT #142 TEST #2 6/10/83

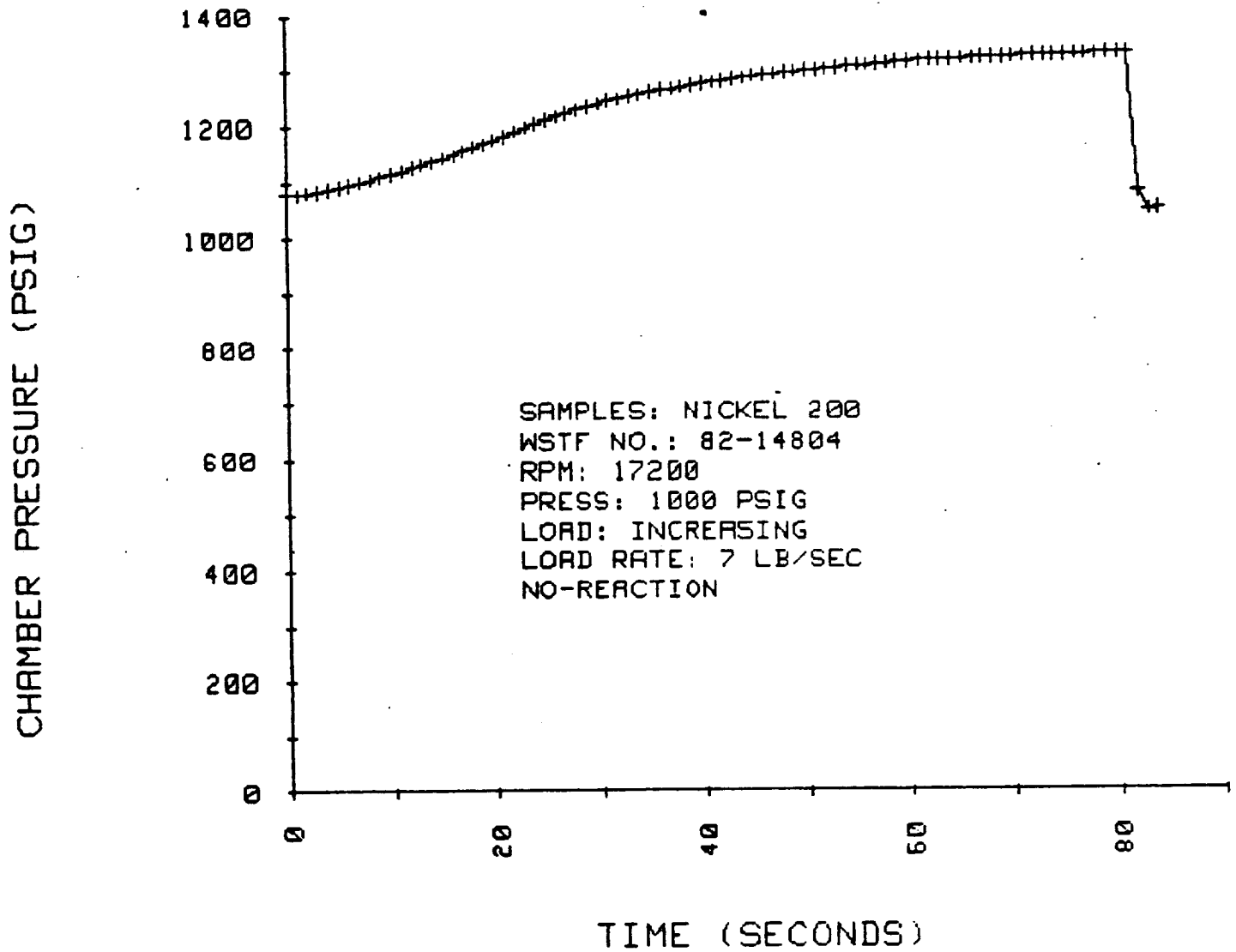
SAMPLES: NICKEL 200
WSTF NO.: 82-14804
RPM: 17200
PRESS: 1000 PSIG
LOAD: INCREASING
LOAD RATE: 7 LB/SEC
NO-REACTION



FRT #142 TEST #2 6/10/83

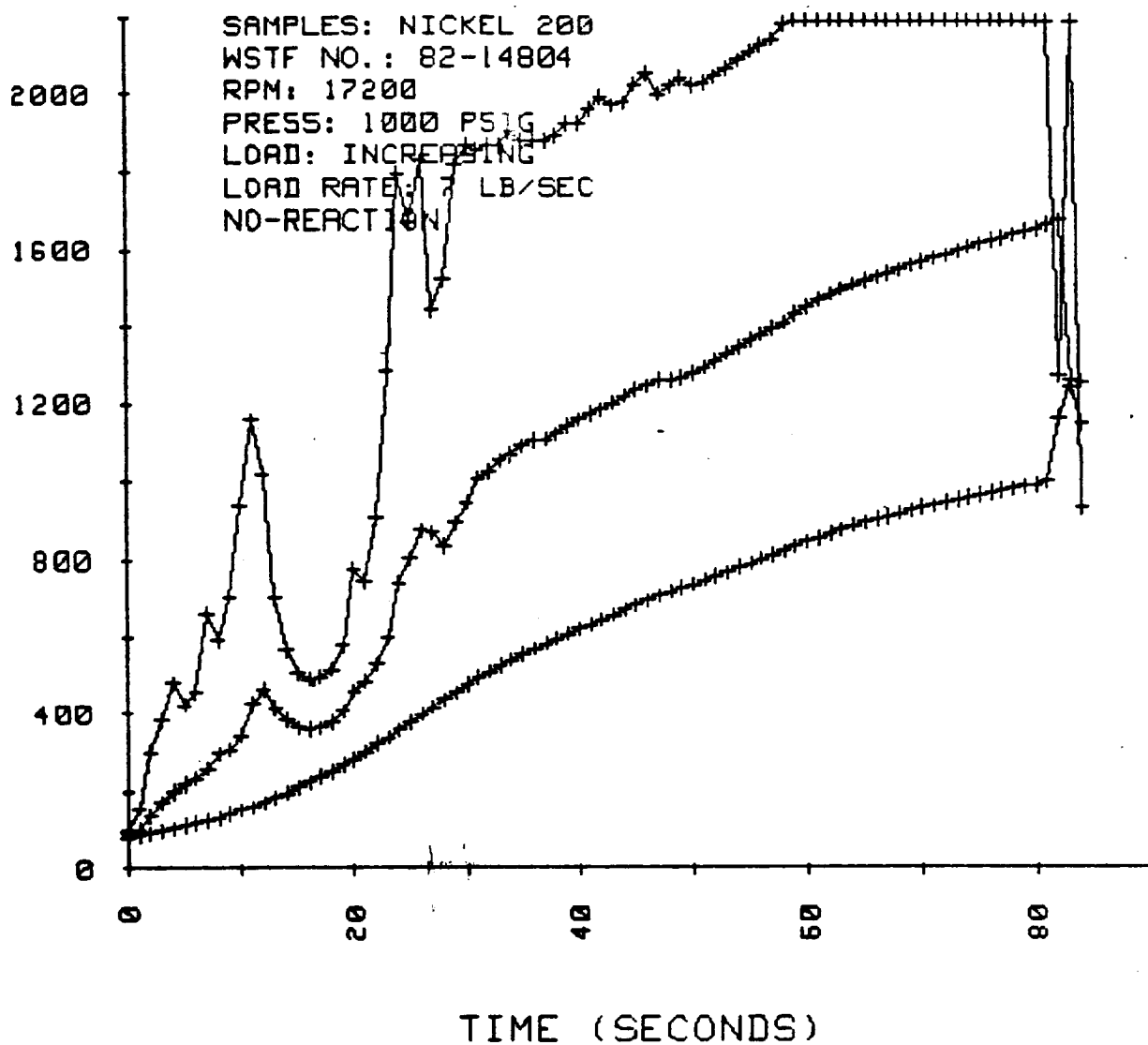


FRT #142 TEST #2 6/10/83



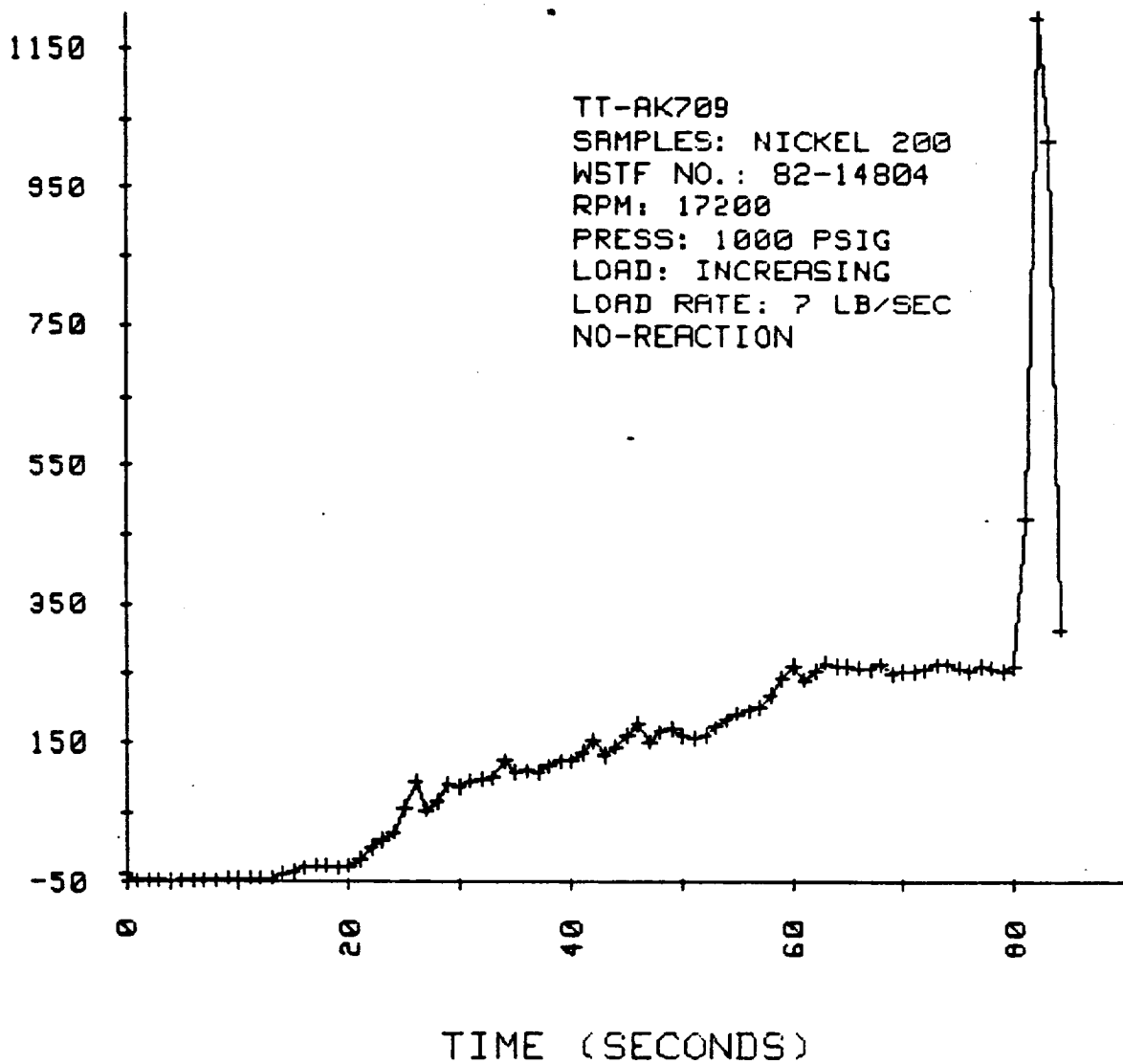
TEMPERATURE (DEG F)

FRT #142 TEST #2 6/10/83



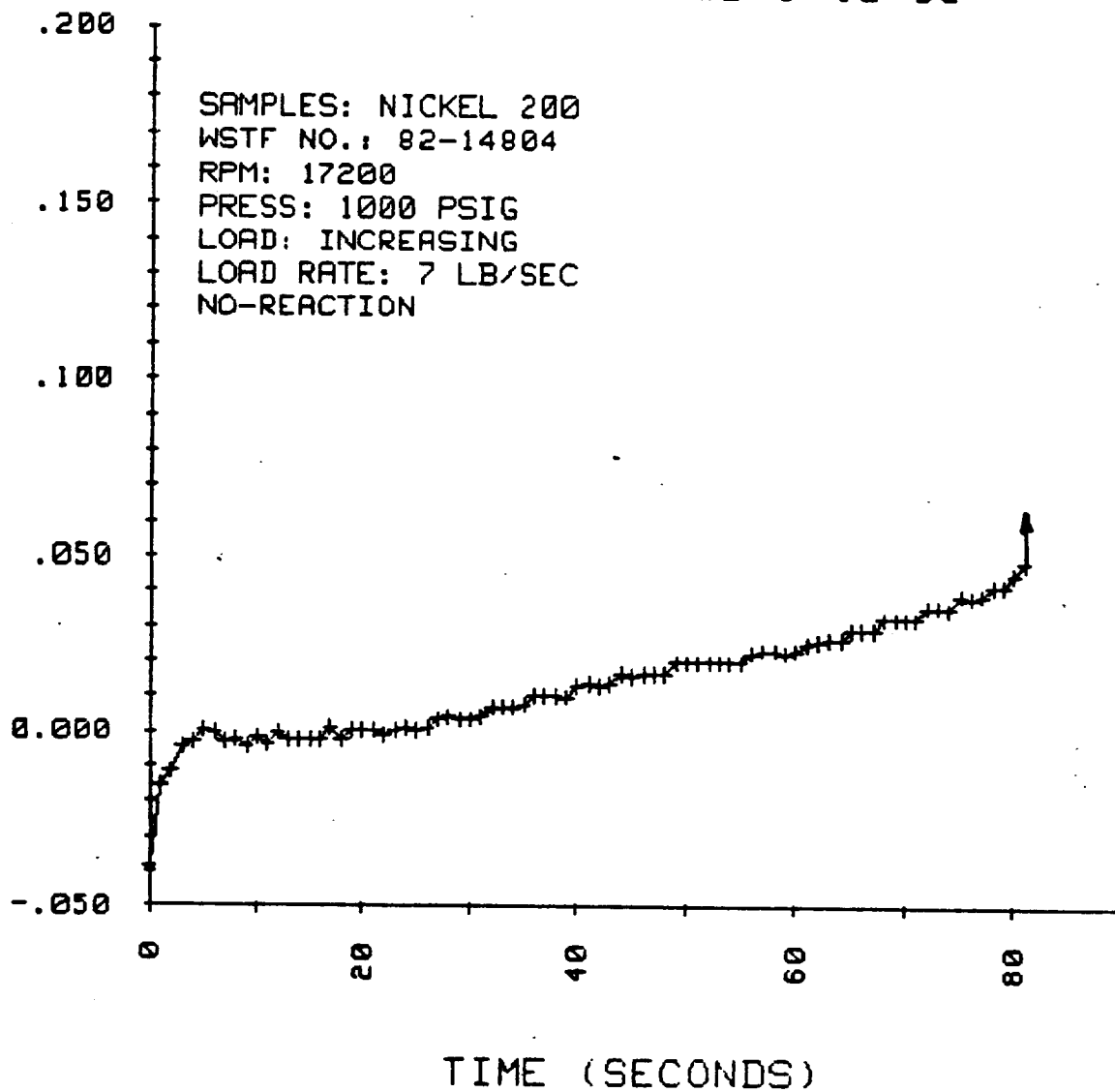
FRT #142 TEST #2 6/10/83

THERMOPILE OUTPUT (1/100MV)

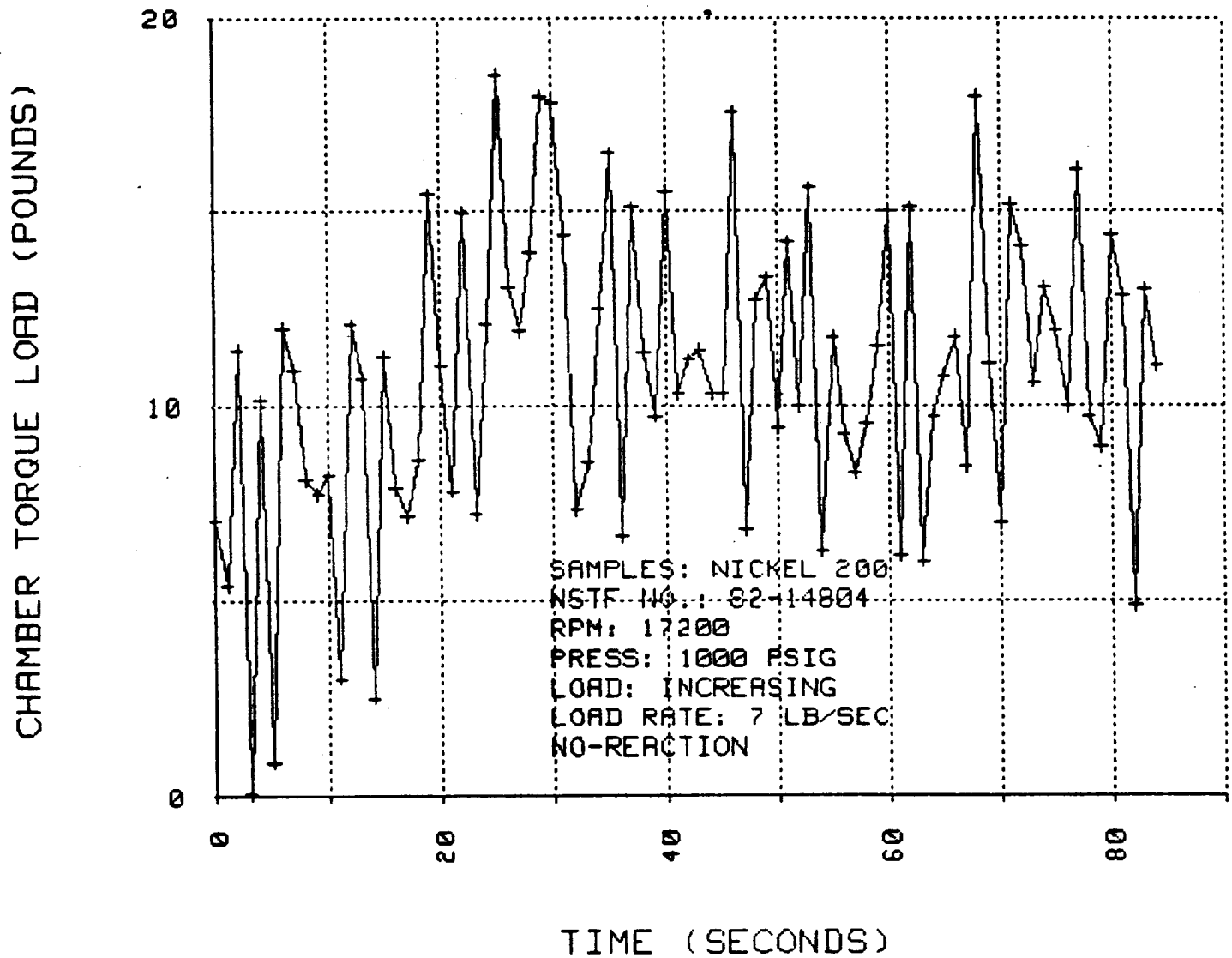


SAMPLE DISPLACEMENT (INCHES)

FRT #142 TEST #2 6/10/83

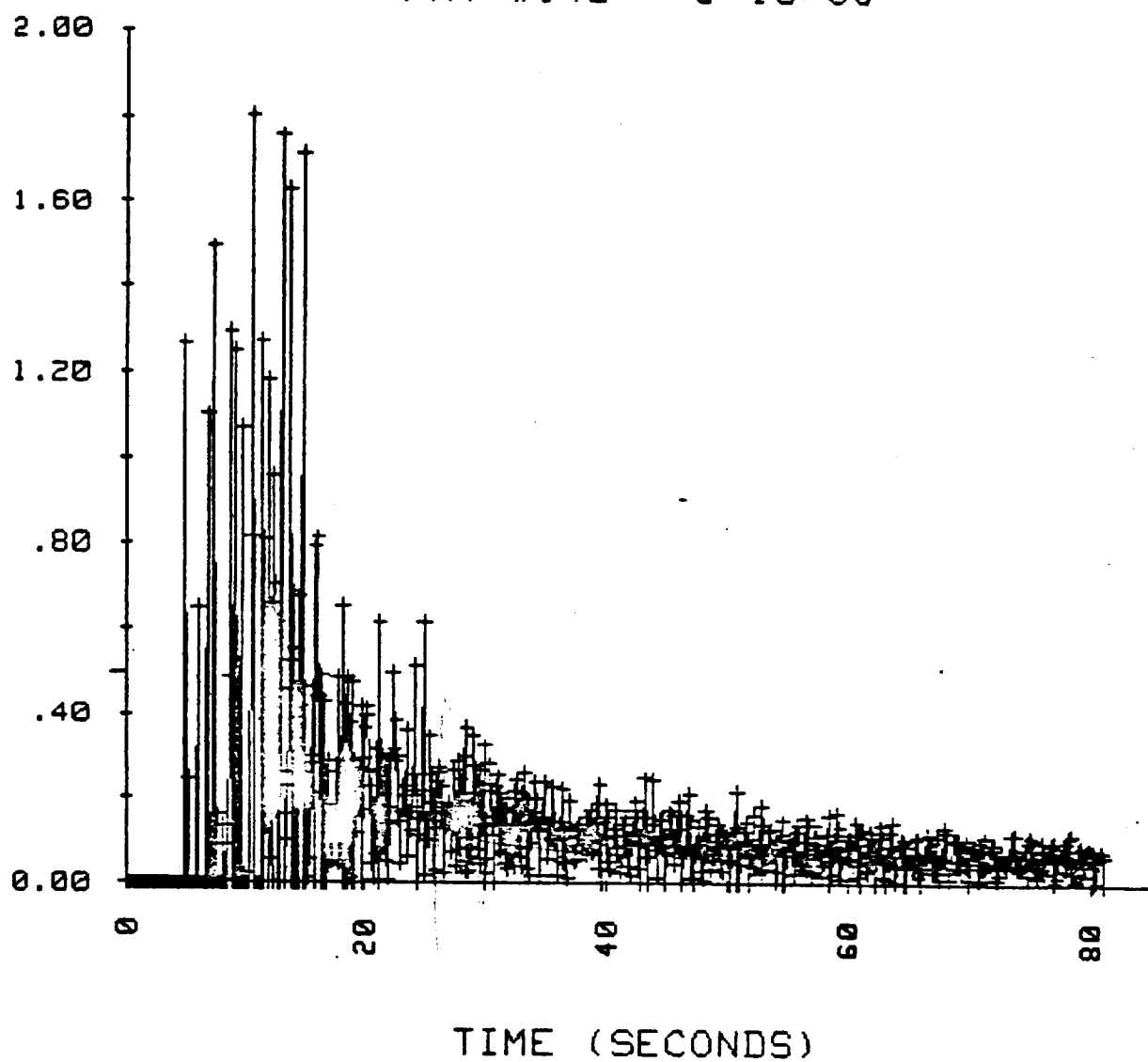


FRT #142 TEST #2 6/10/83

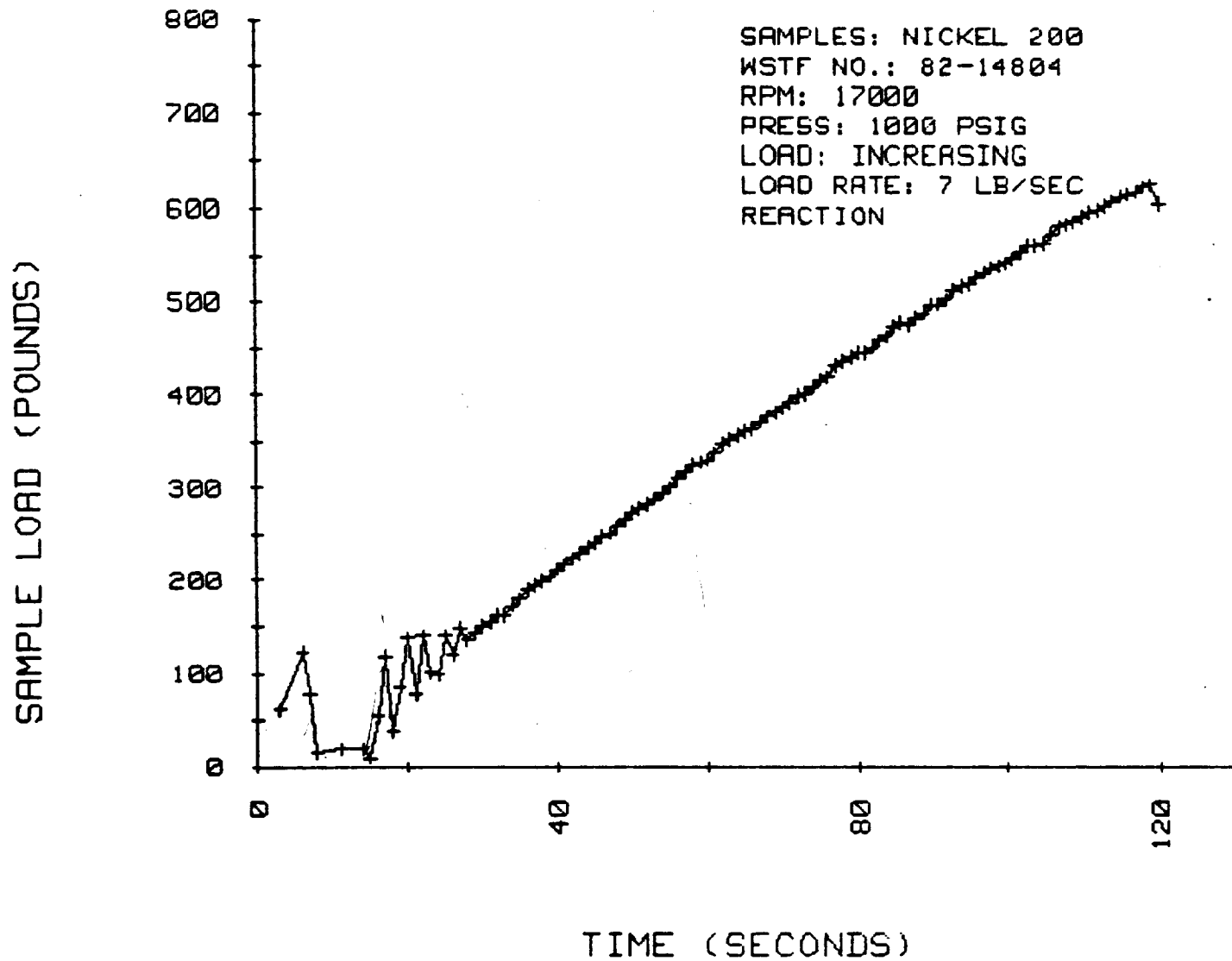


FRT #142 6/10/83

COEFFICIENT OF FRICTION

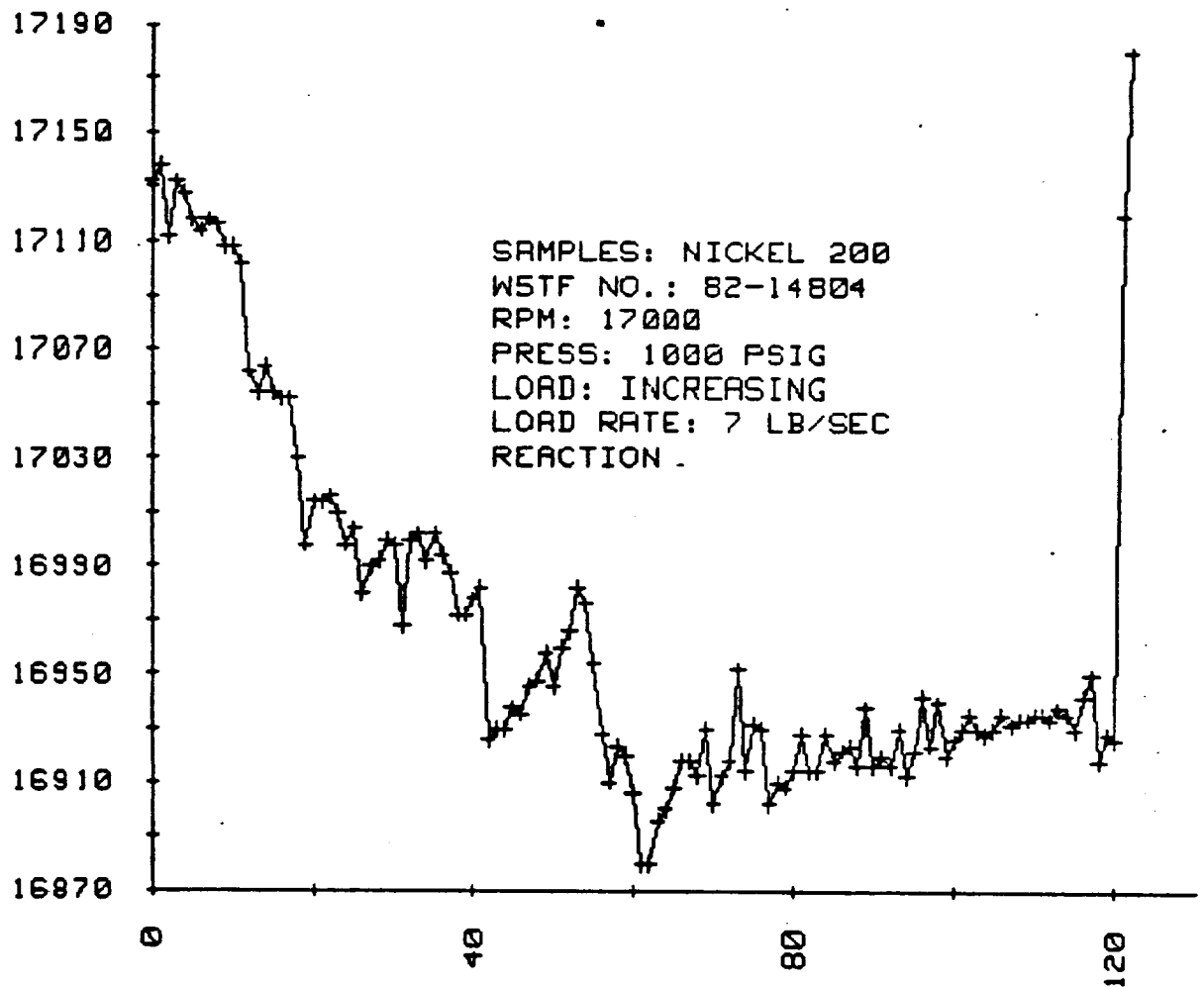


FRT #144 TEST #1 6/13/83



FRT #144 TEST #1 6/13/83

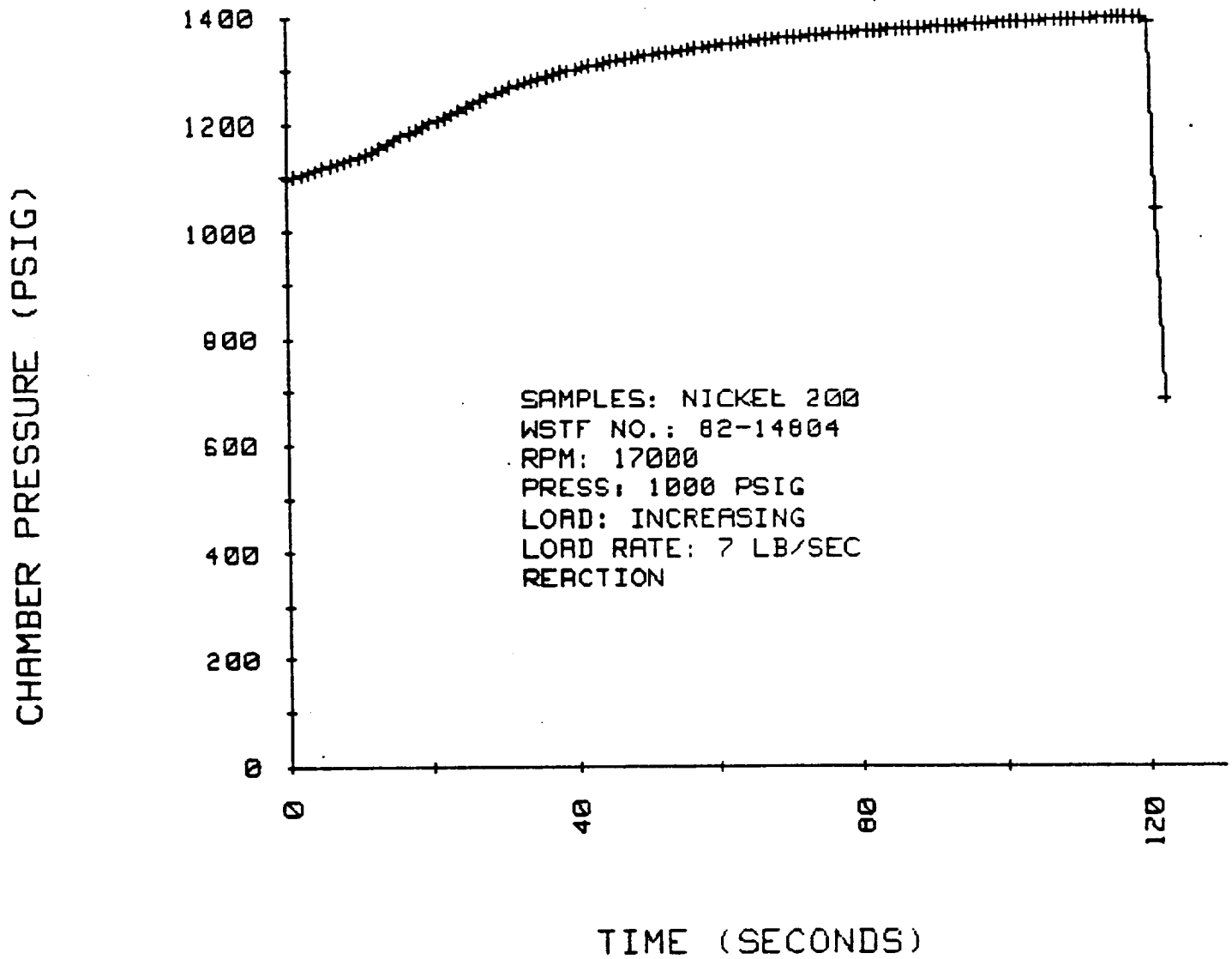
RPM (REVOLUTIONS PER MINUTE)



SAMPLES: NICKEL 200
WSTF NO.: 82-14804
RPM: 17000
PRESS: 1000 PSIG
LOAD: INCREASING
LOAD RATE: 7 LB/SEC
REACTION .

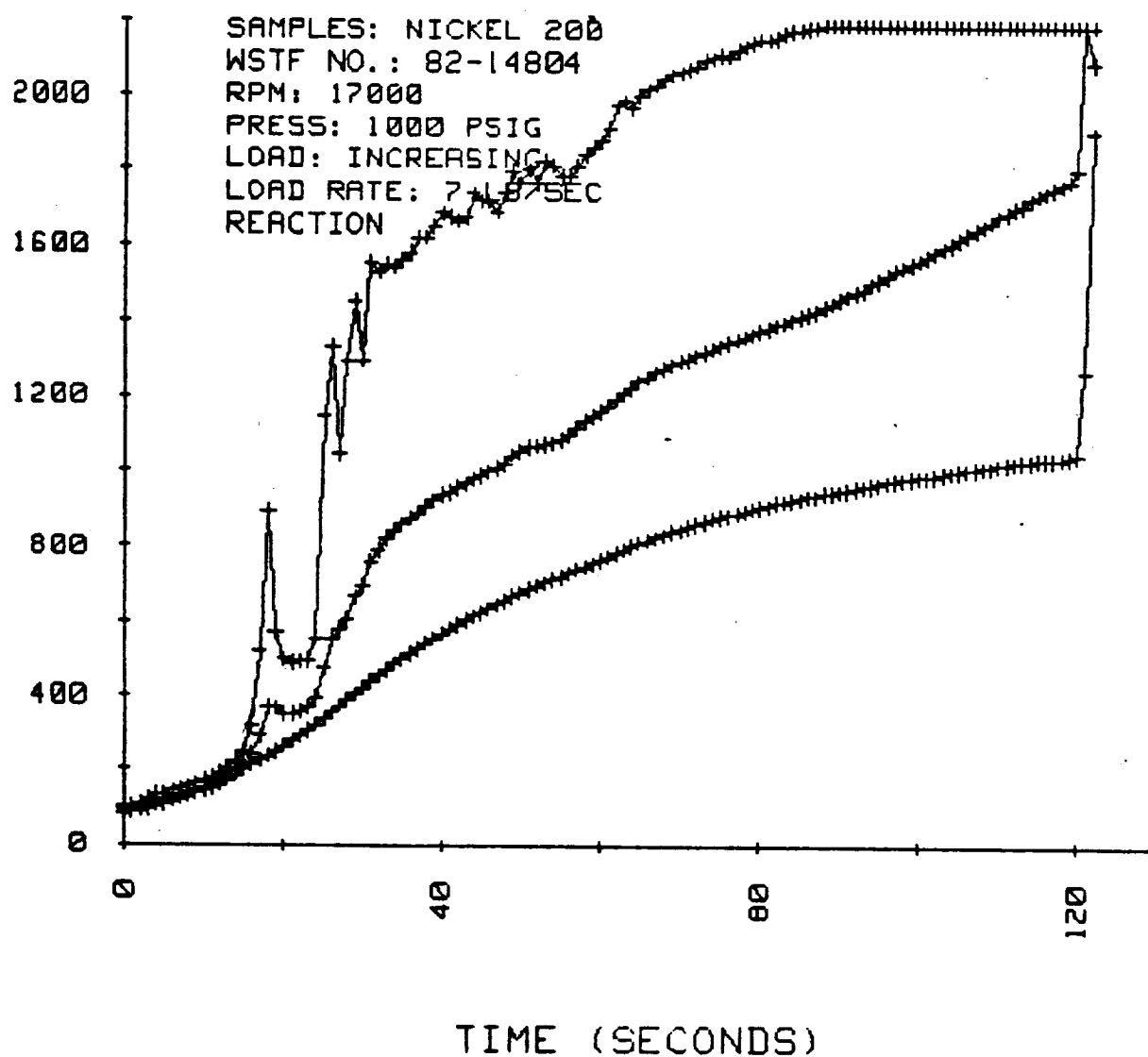
TIME (SECONDS)

FRT #144 TEST #1 6/13/83



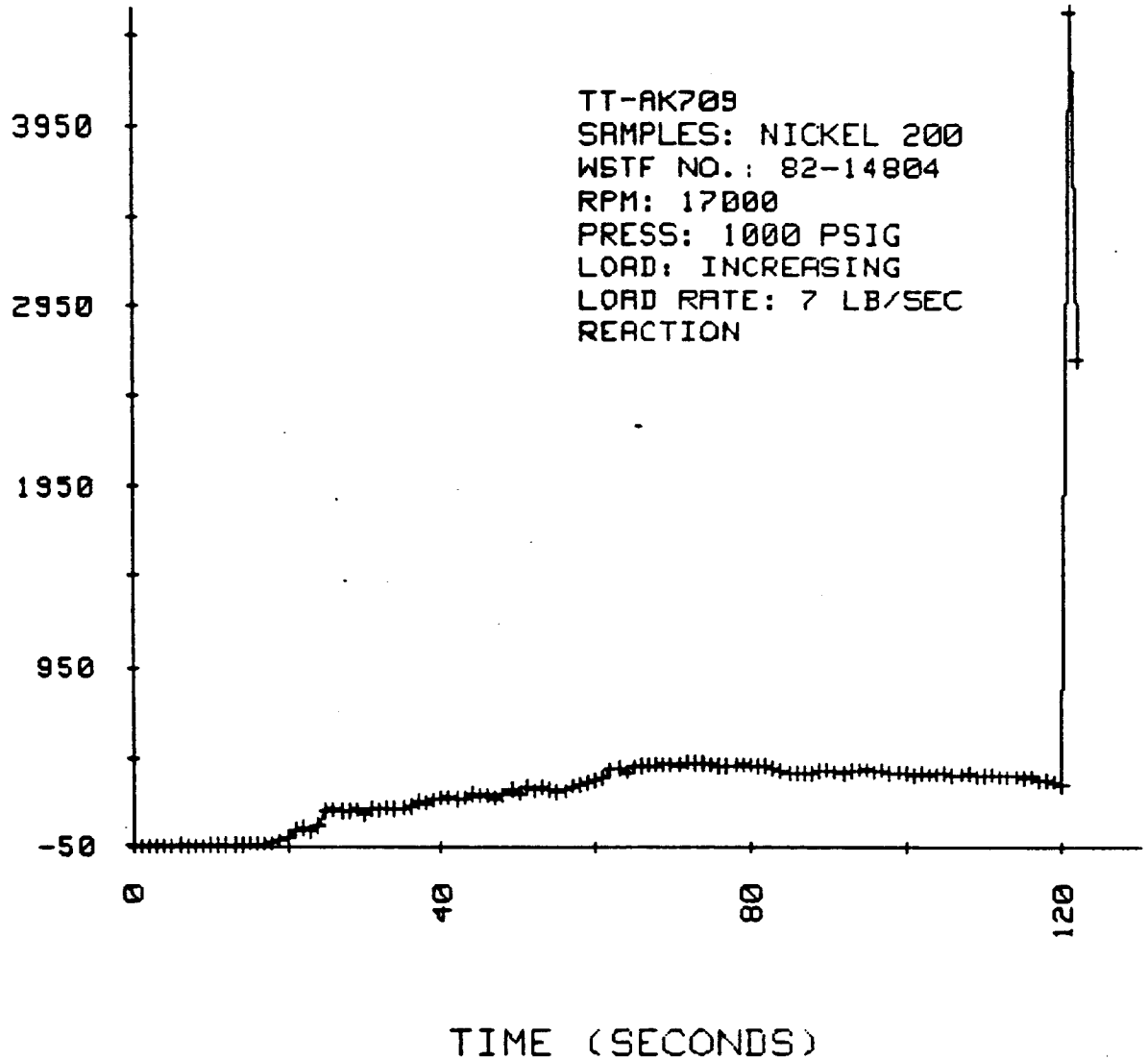
TEMPERATURE (DEG F)

FRT #144 TEST #1 6/13/83



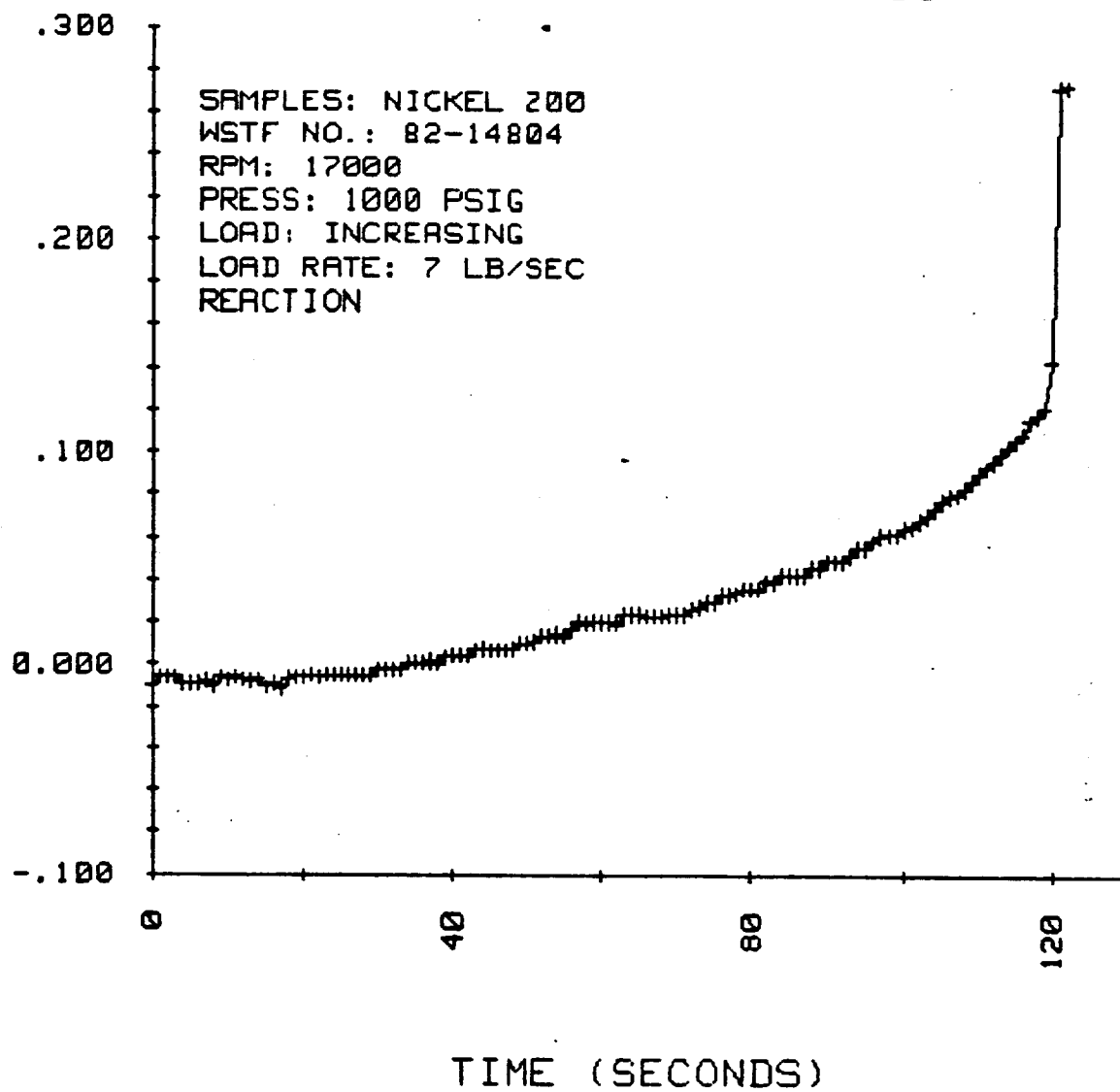
FRT #144 TEST #1 6/13/83

THERMOPILE OUTPUT (1/100MV)



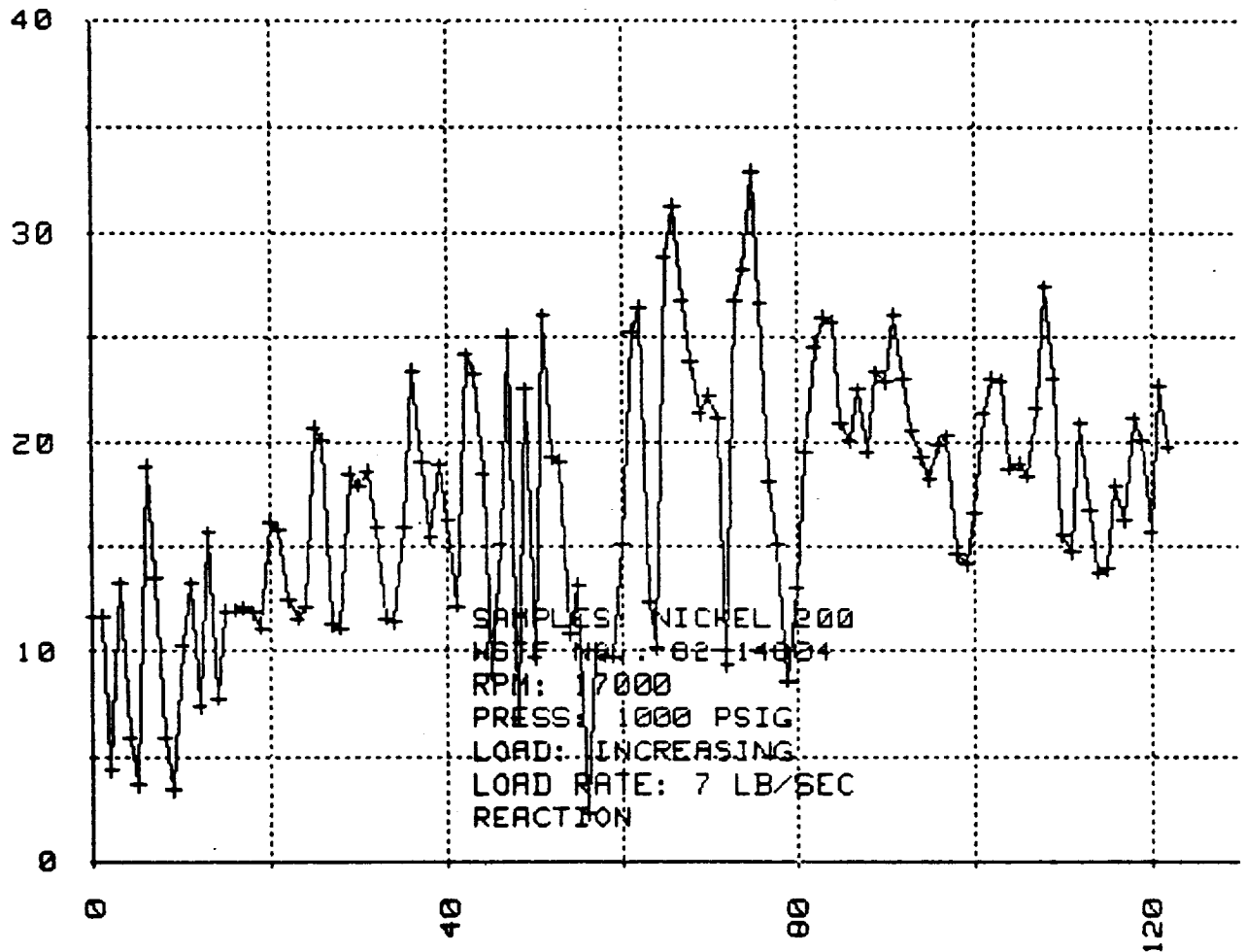
SAMPLE DISPLACEMENT (INCHES)

FRT #144 TEST #1 6/13/83



FRT #144 TEST #1 6/13/83

CHAMBER TORQUE LOAD (POUNDS)

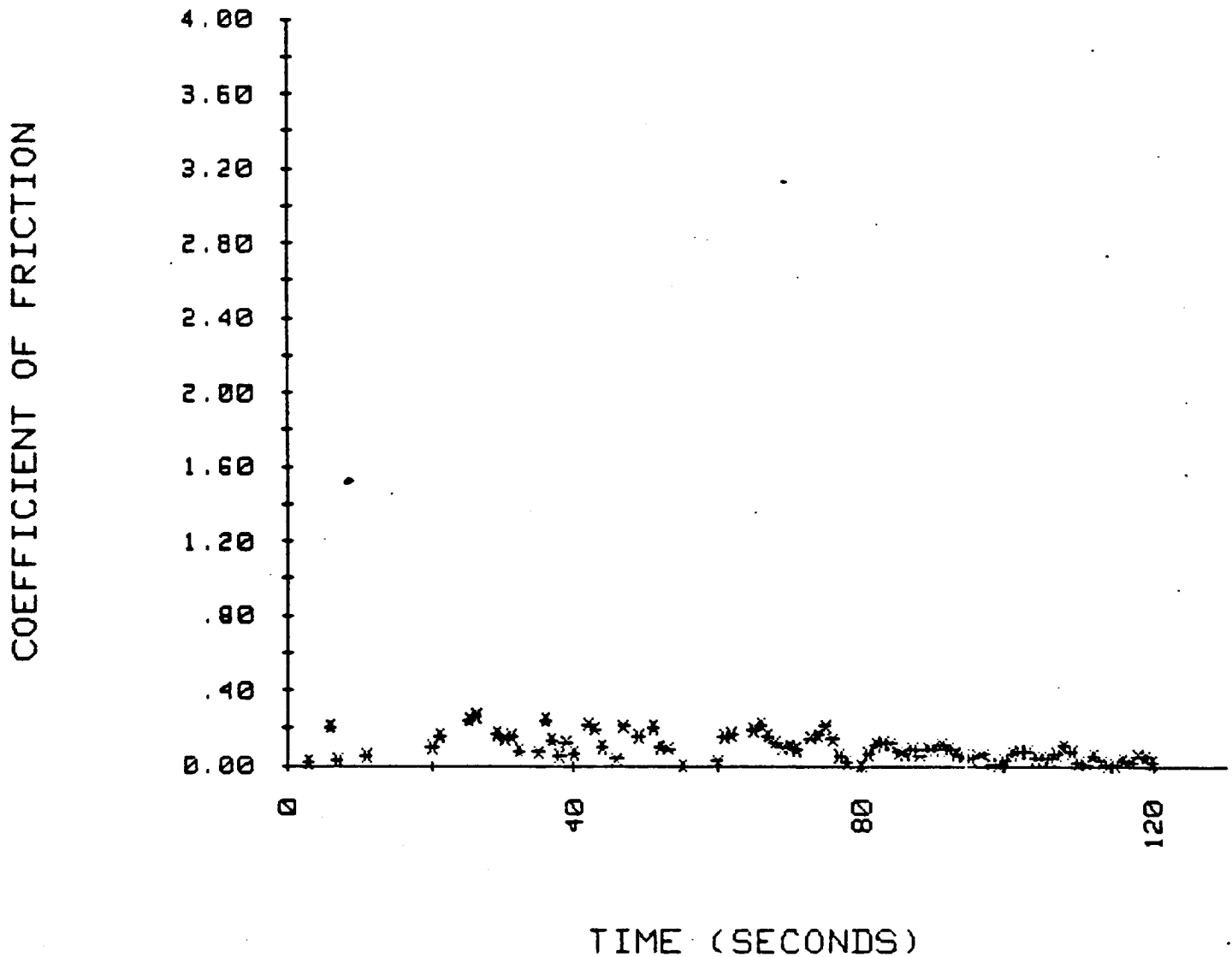


TIME (SECONDS)

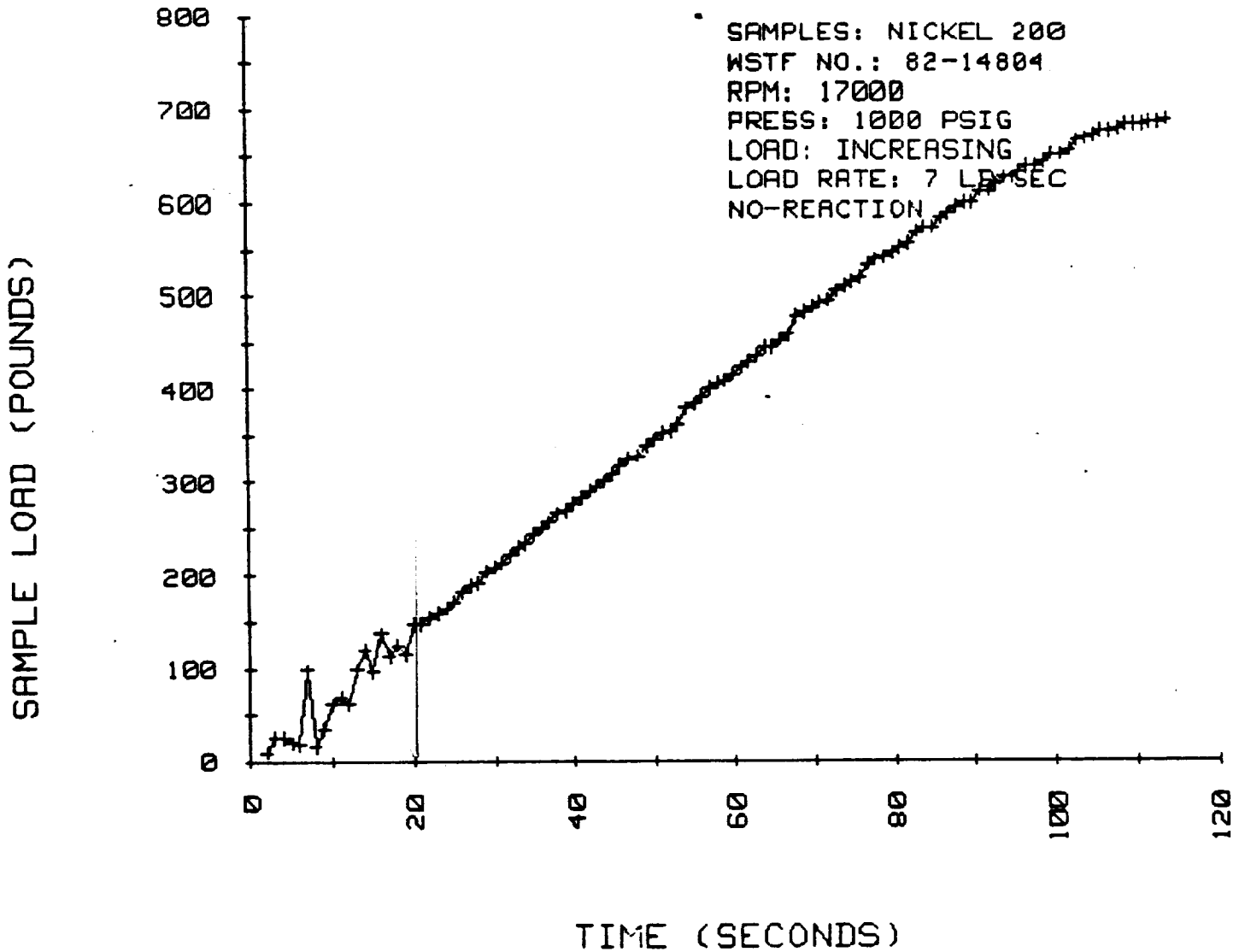
FRT #144

SAMPLES: NICKEL 200
TEST RESULTS: REACTION

SPEED: 17000 RPM (67 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (24 PSI/SEC)

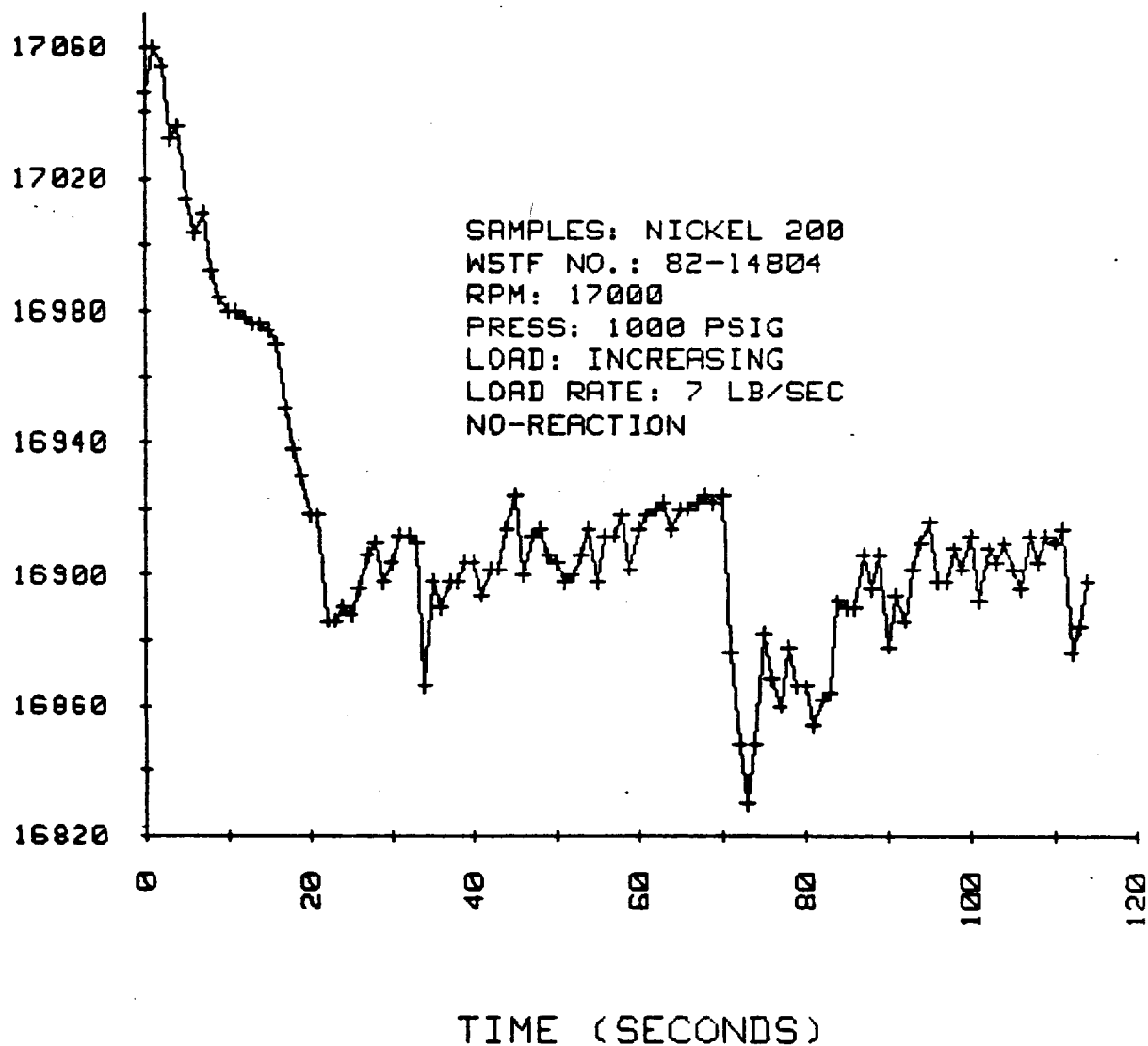


FRT #161 TEST #1 6/27/83



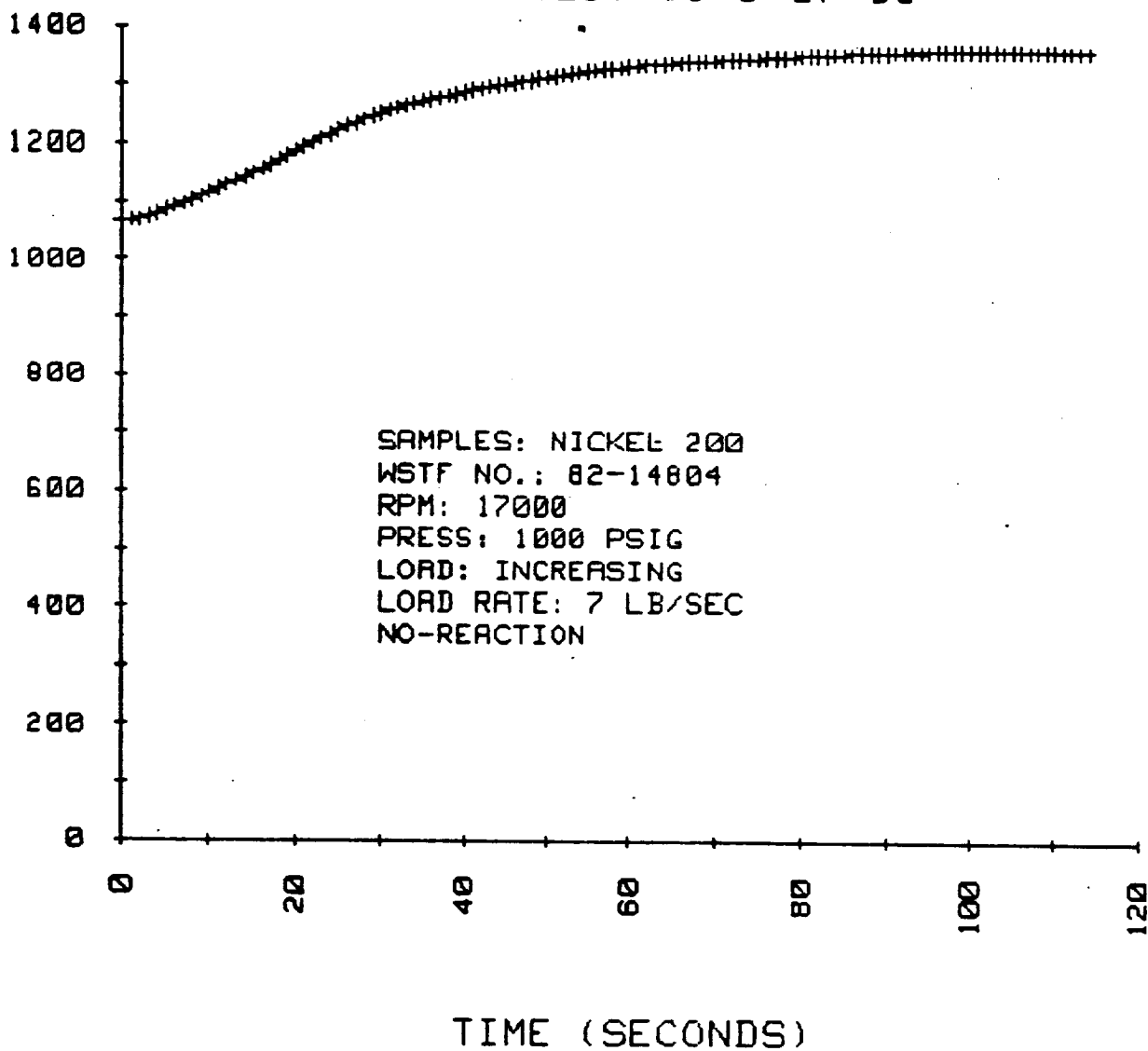
FRT #161 TEST #1 6/27/83

RPM (REVOLUTIONS PER MINUTE)

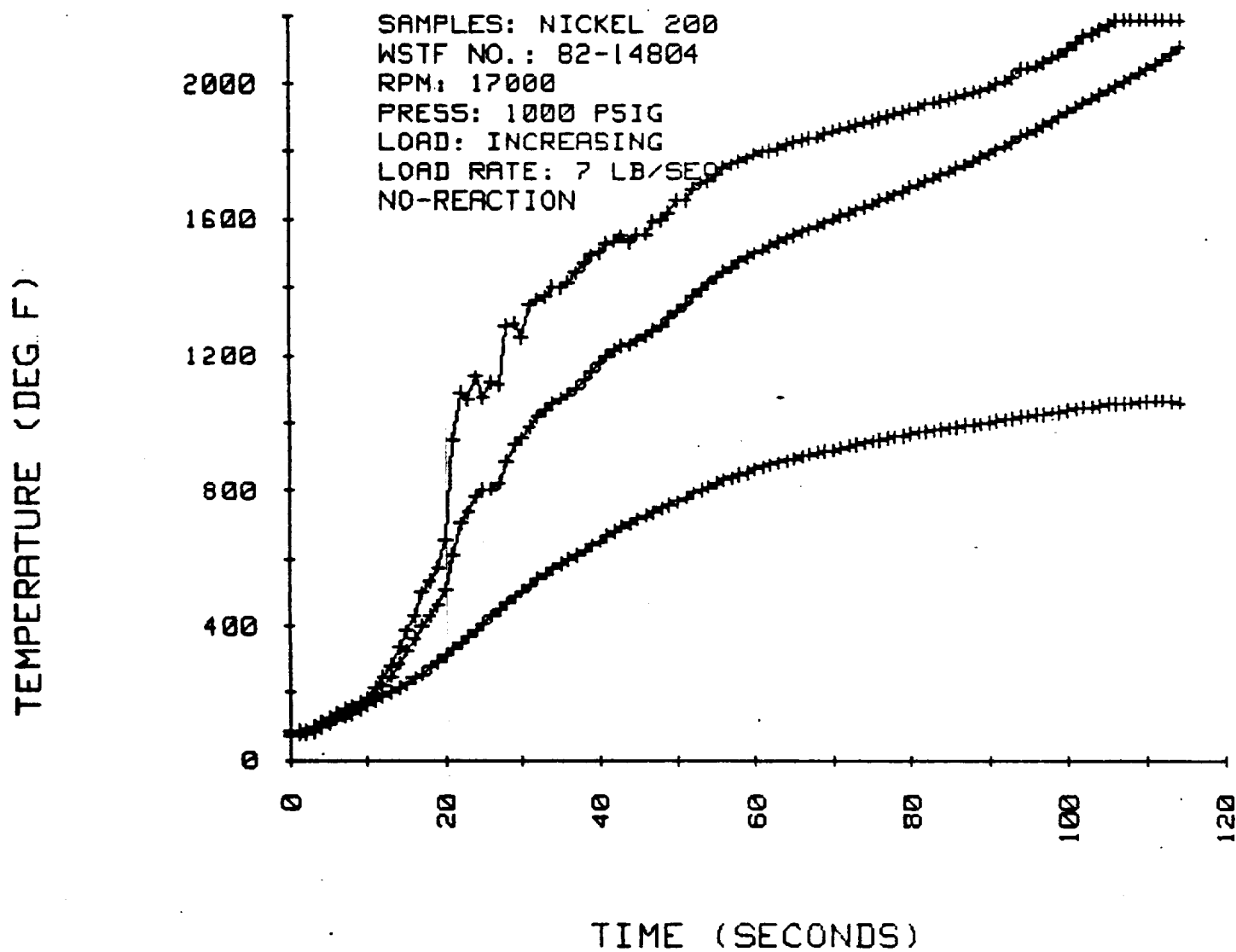


CHAMBER PRESSURE (PSIG)

FRT #161 TEST #1 6/27/83

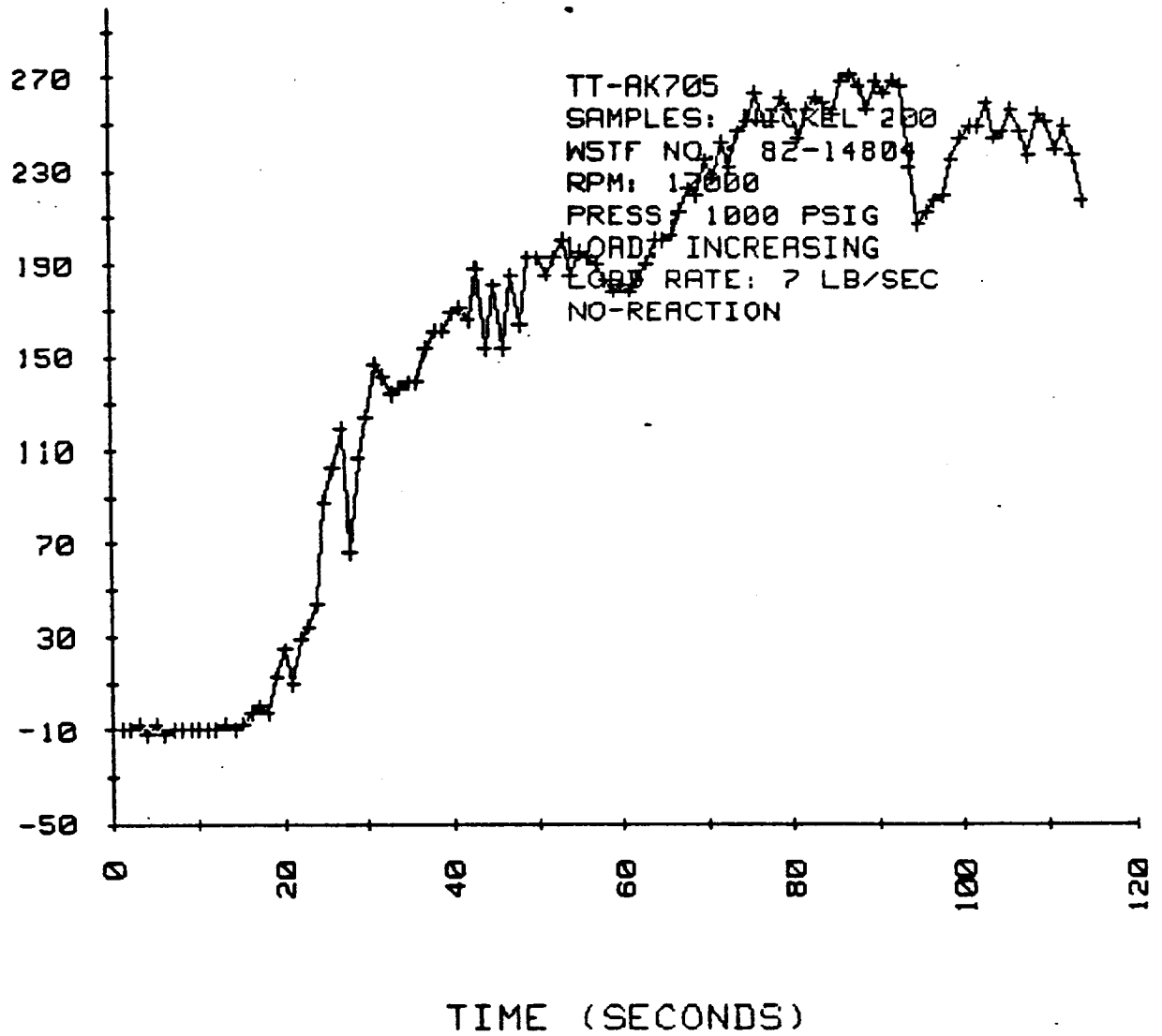


FRT #161 TEST #1 6/27/83



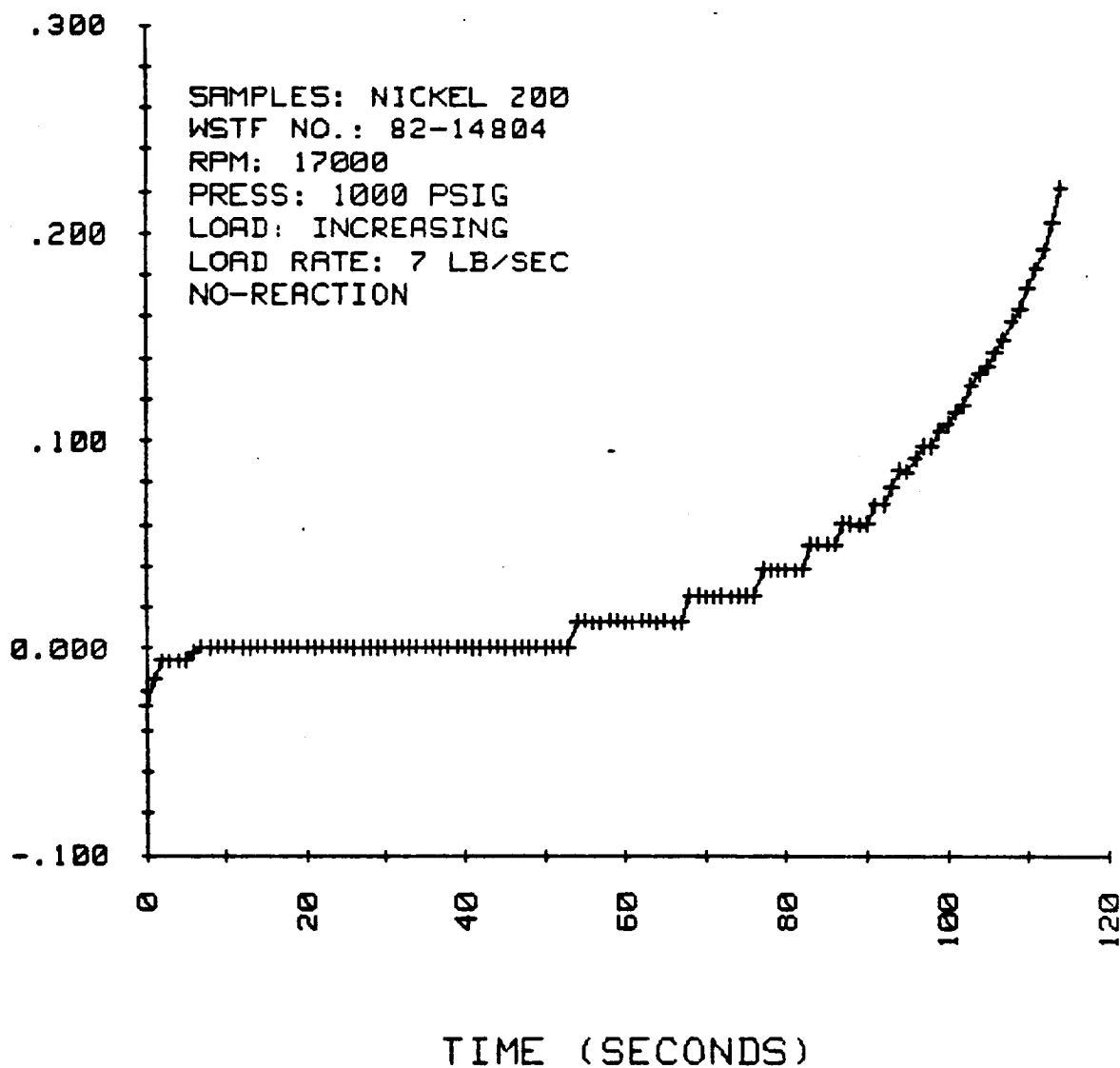
FRT #161 TEST #1 6/27/83

THERMOPILE OUTPUT (1/100MV)



SAMPLE DISPLACEMENT (INCHES)

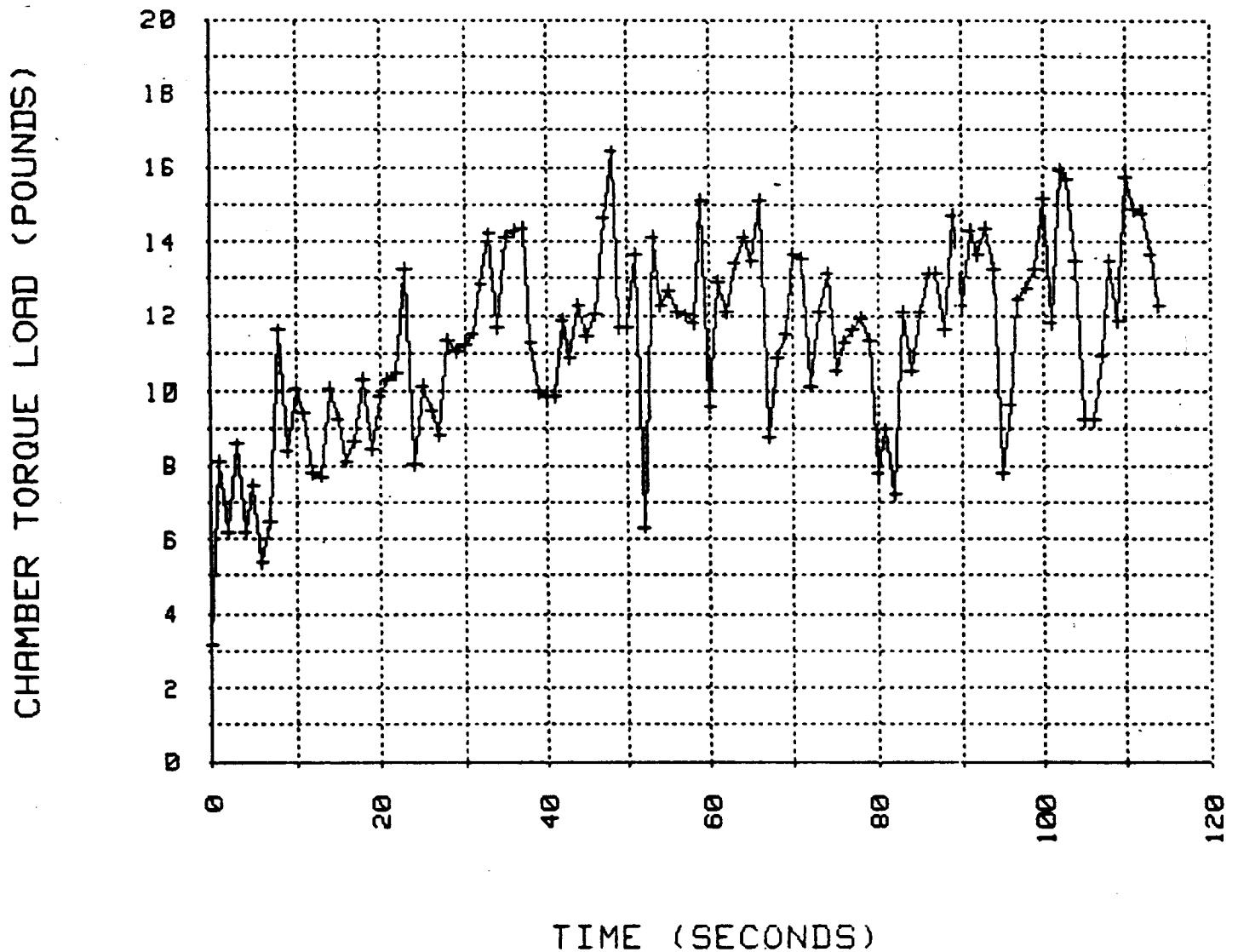
FRT #161 TEST #1 6/27/83



FRT #161

SAMPLES: NICKEL 200
TEST RESULTS: NO-REACTION

SPEED: 17000 RPM (67 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (24 PSI/SEC)



FRT #177

SAMPLES: SILICON CARBIDE

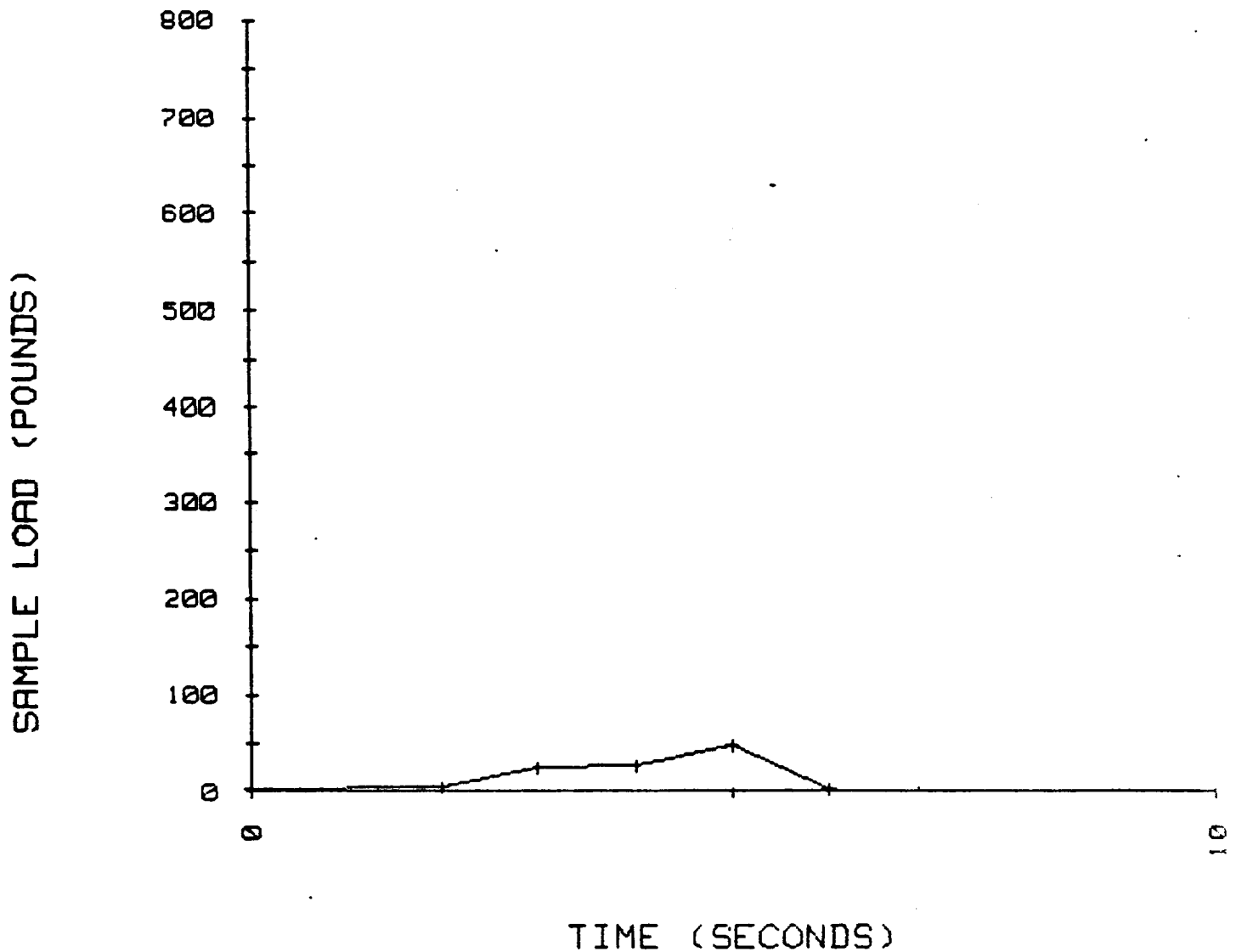
TEST RESULTS: SHATTER

SPEED: 17000 RPM (67 FT/SEC)

PRESS: 1000 PSIG

TYPE OF LOAD: INCREASING

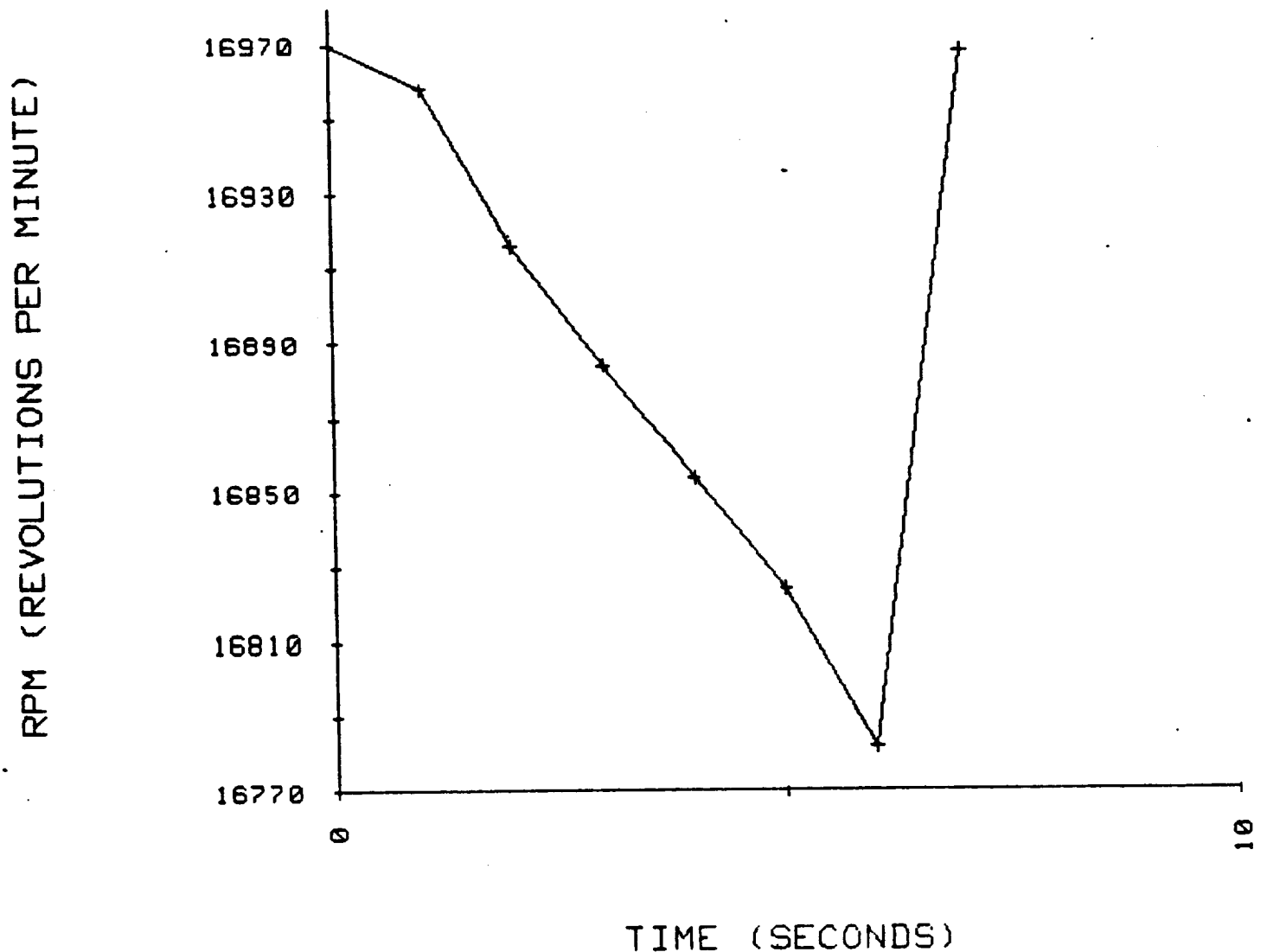
LOAD RATE: 7 LB/SEC (25 PSI/SEC)



FRT #177

SAMPLES: SILICON CARBIDE
TEST RESULTS: SHATTER

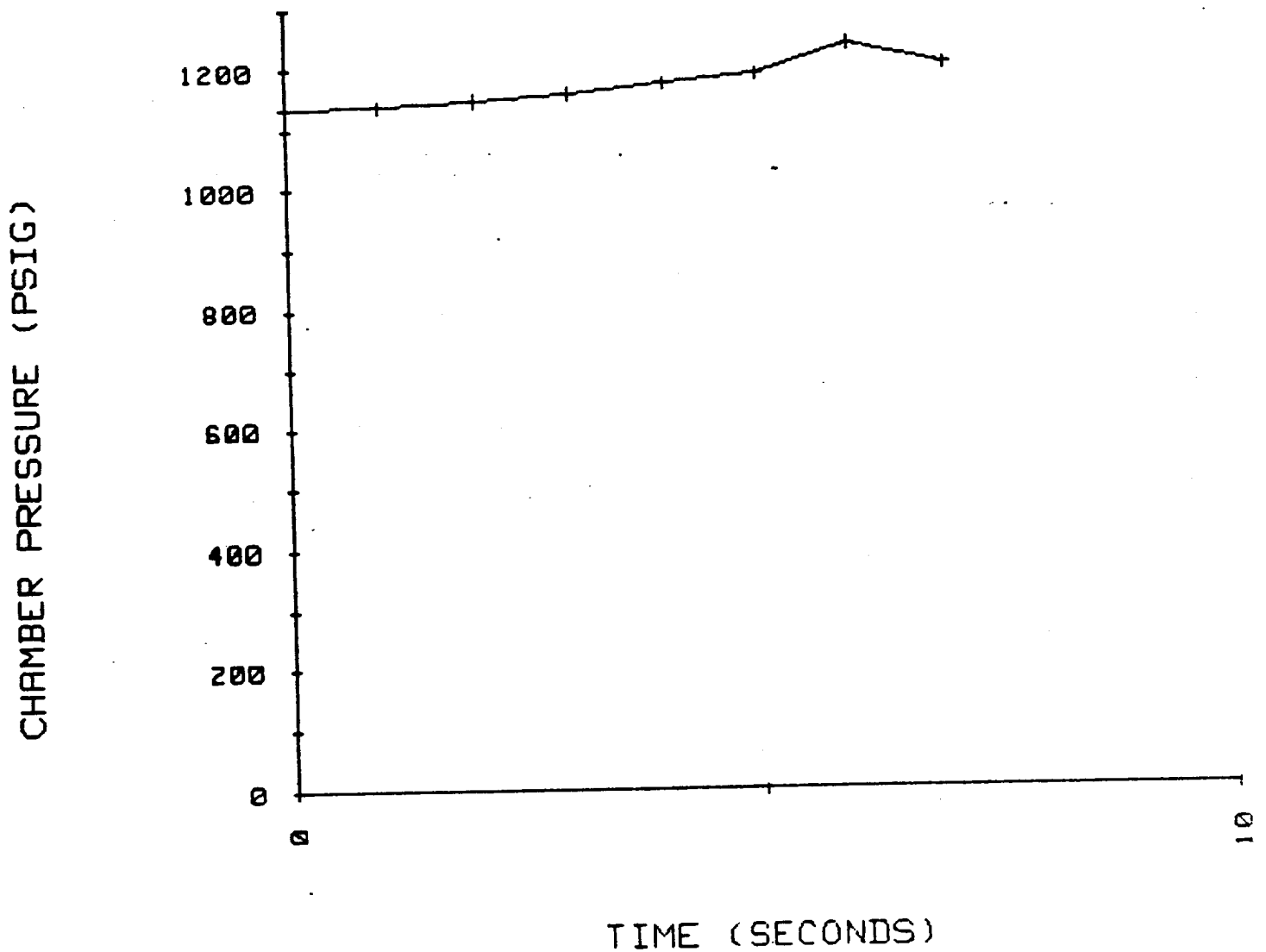
SPEED: 17000 RPM (67 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (25 PSI/SEC)



FRT #177

SAMPLES: SILICON CARBIDE
TEST RESULTS: SHATTER

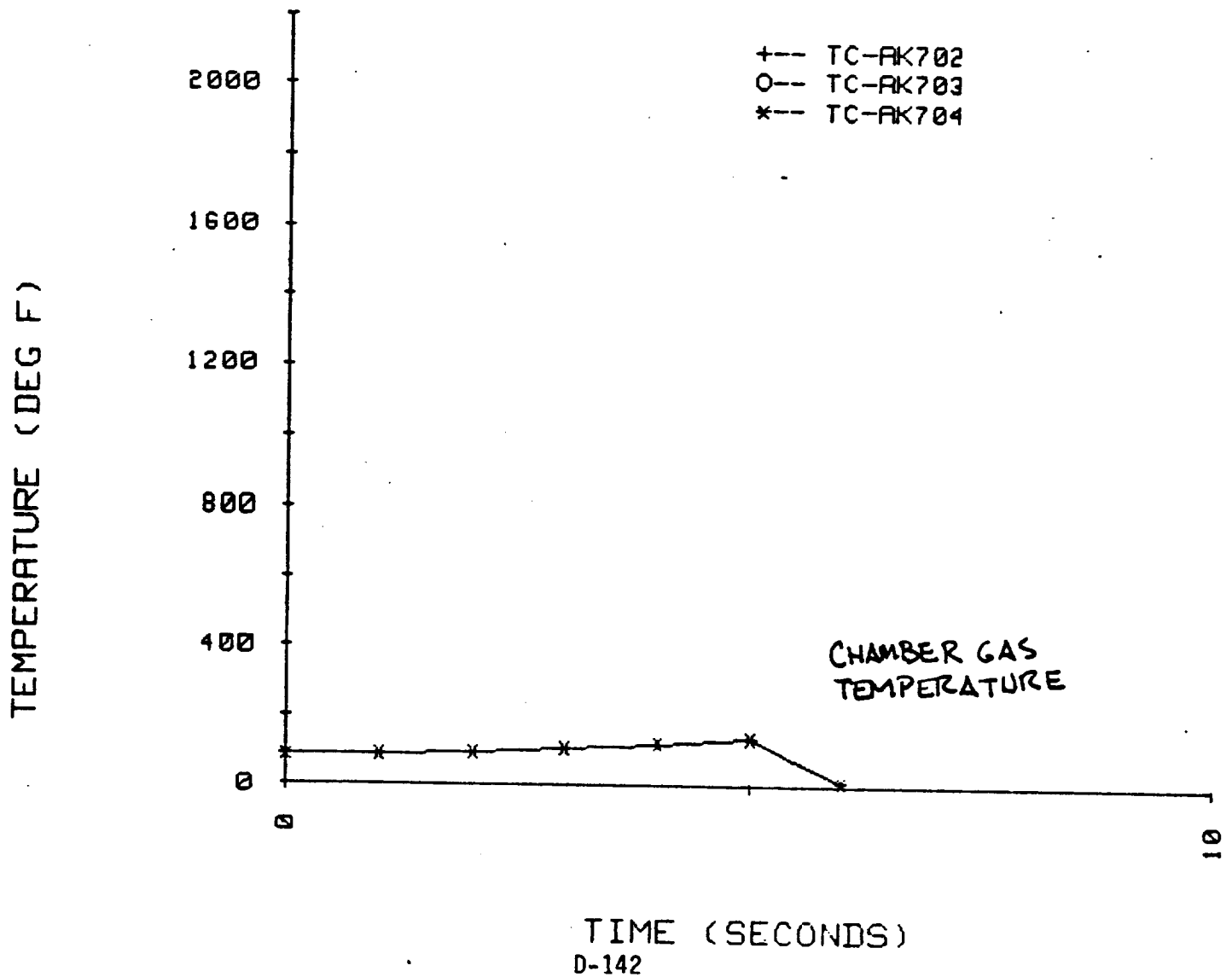
SPEED: 17000 RPM (67 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (25 PSI/SEC)



FRT #177

SAMPLES: SILICON CARBIDE
TEST RESULTS: SHATTER

SPEED: 17000 RPM (67 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (25 PSI/SEC)



FRT #177

SAMPLES: SILICON CARBIDE

TEST RESULTS: SHATTER

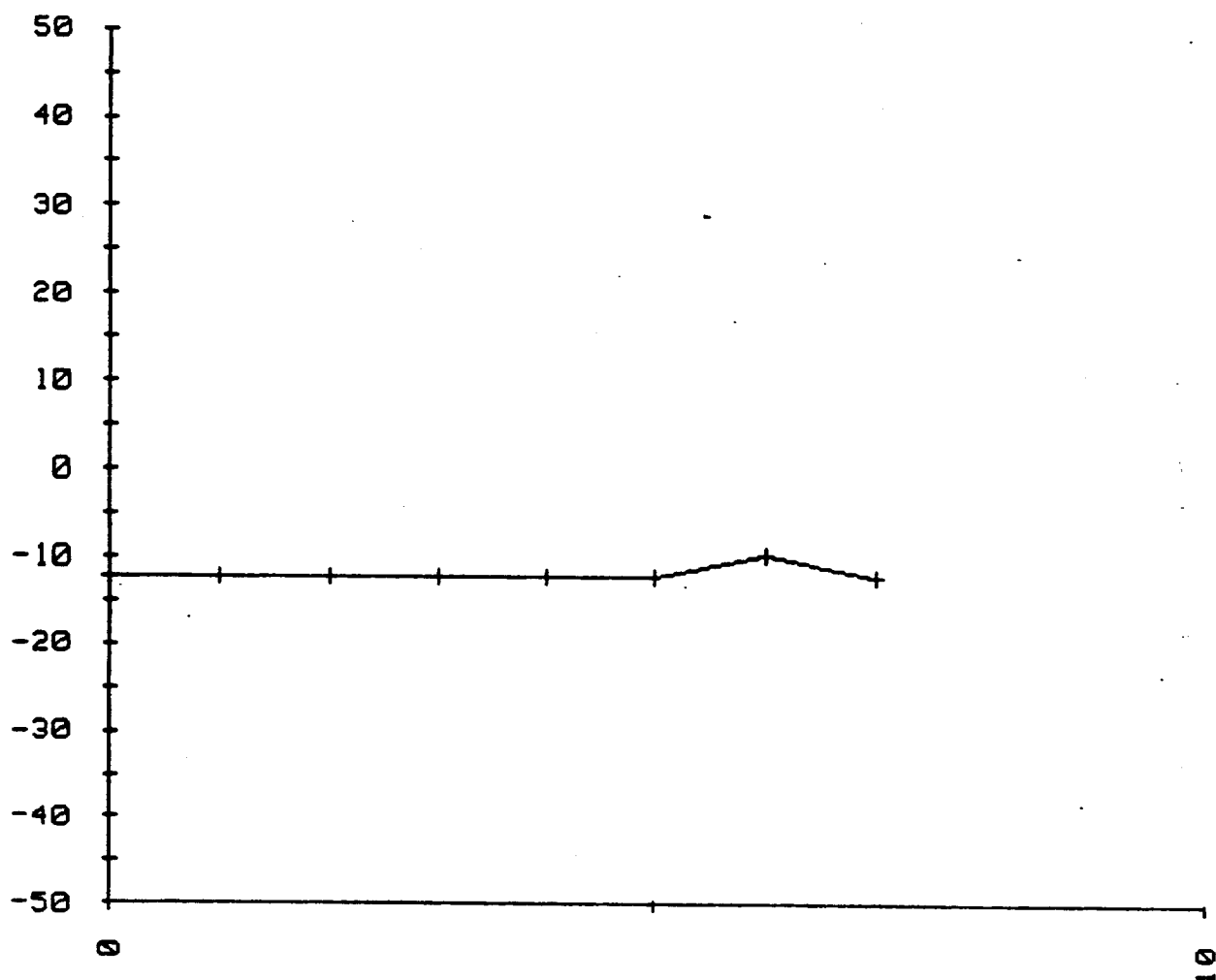
SPEED: 17000 RPM (67 FT/SEC)

PRESS: 1000 PSIG

TYPE OF LOAD: INCREASING

LOAD RATE: 7 LB/SEC (25 PSI/SEC)

THERMOPILE OUTPUT (1/100MV)
TT-AK705



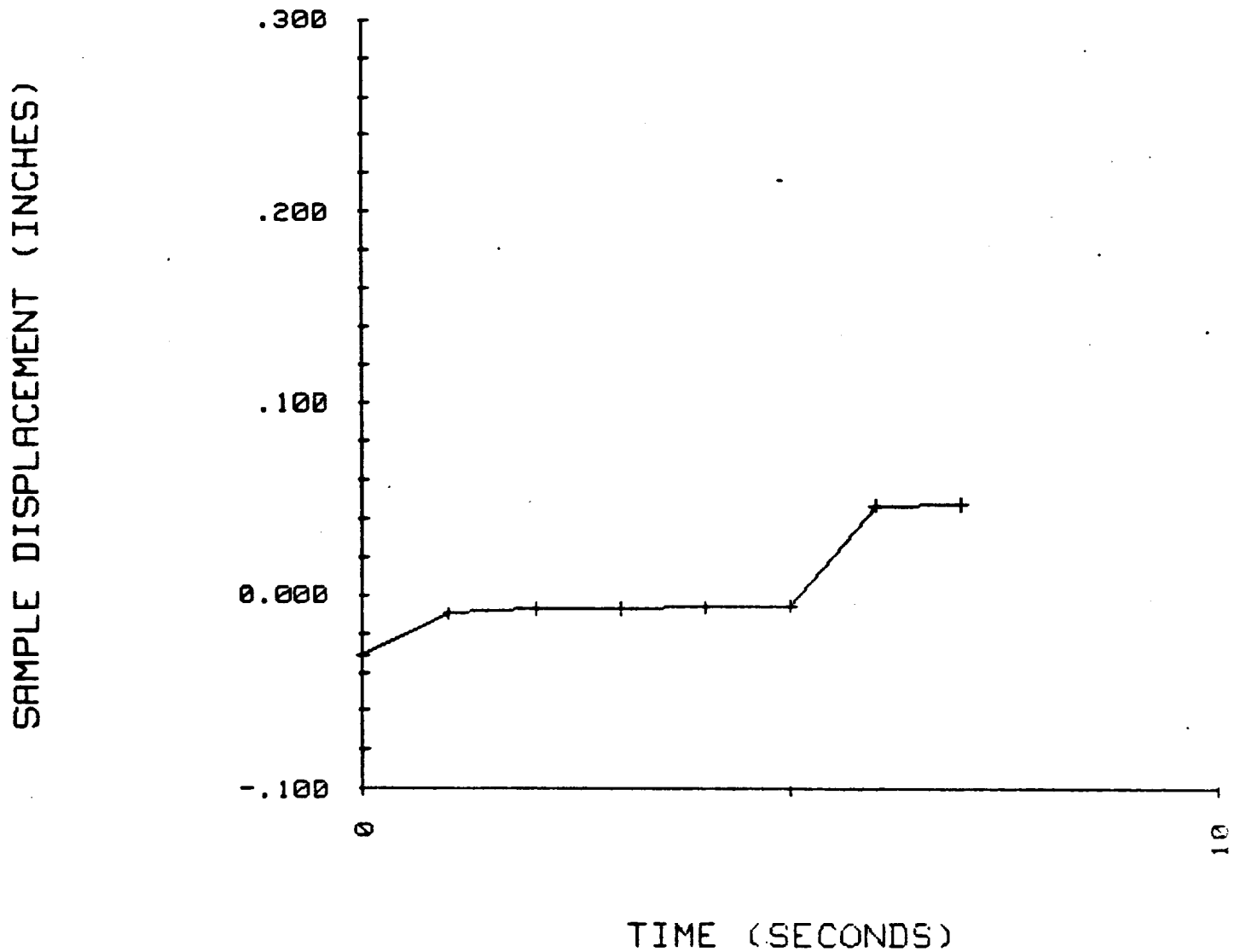
TIME (SECONDS)

D-143

FRT #177

SAMPLES: SILICON CARBIDE
TEST RESULTS: SHATTER

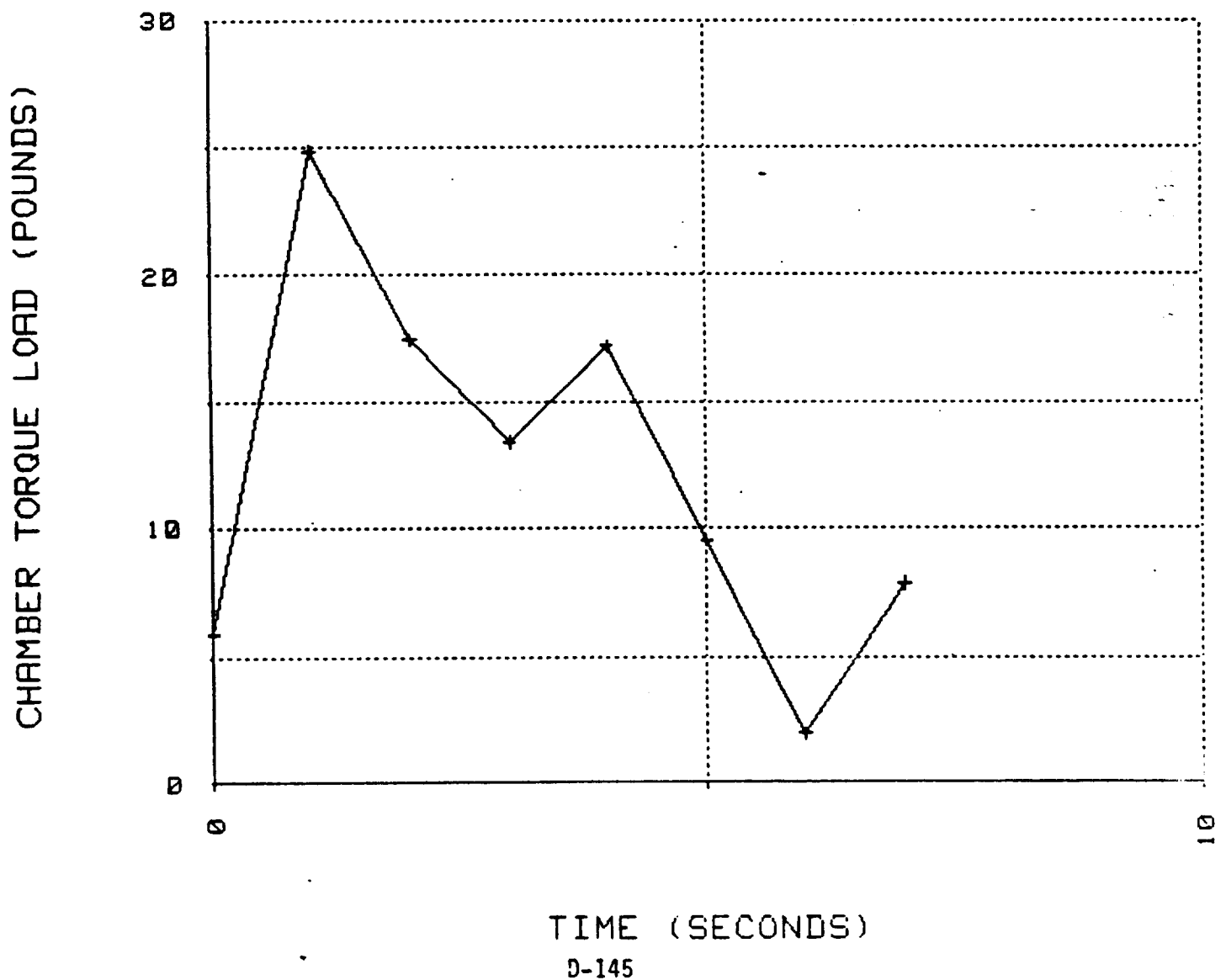
SPEED: 17000 RPM (67 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (25 PSI/SEC)



FRT #177

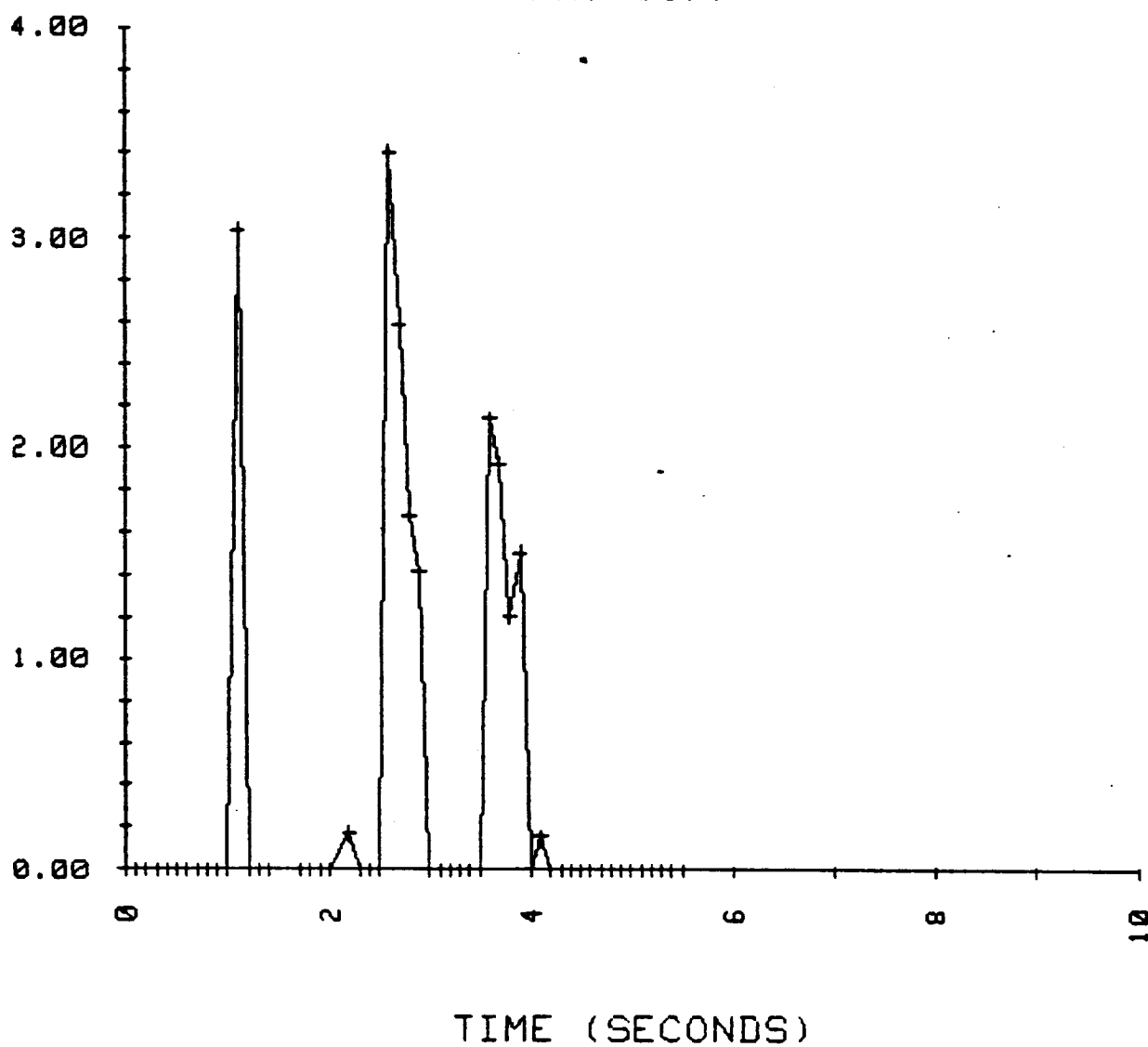
SAMPLES: SILICON CARBIDE
TEST RESULTS: SHATTER

SPEED: 17000 RPM (67 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (25 PSI/SEC)



COEFFICIENT OF FRICTION

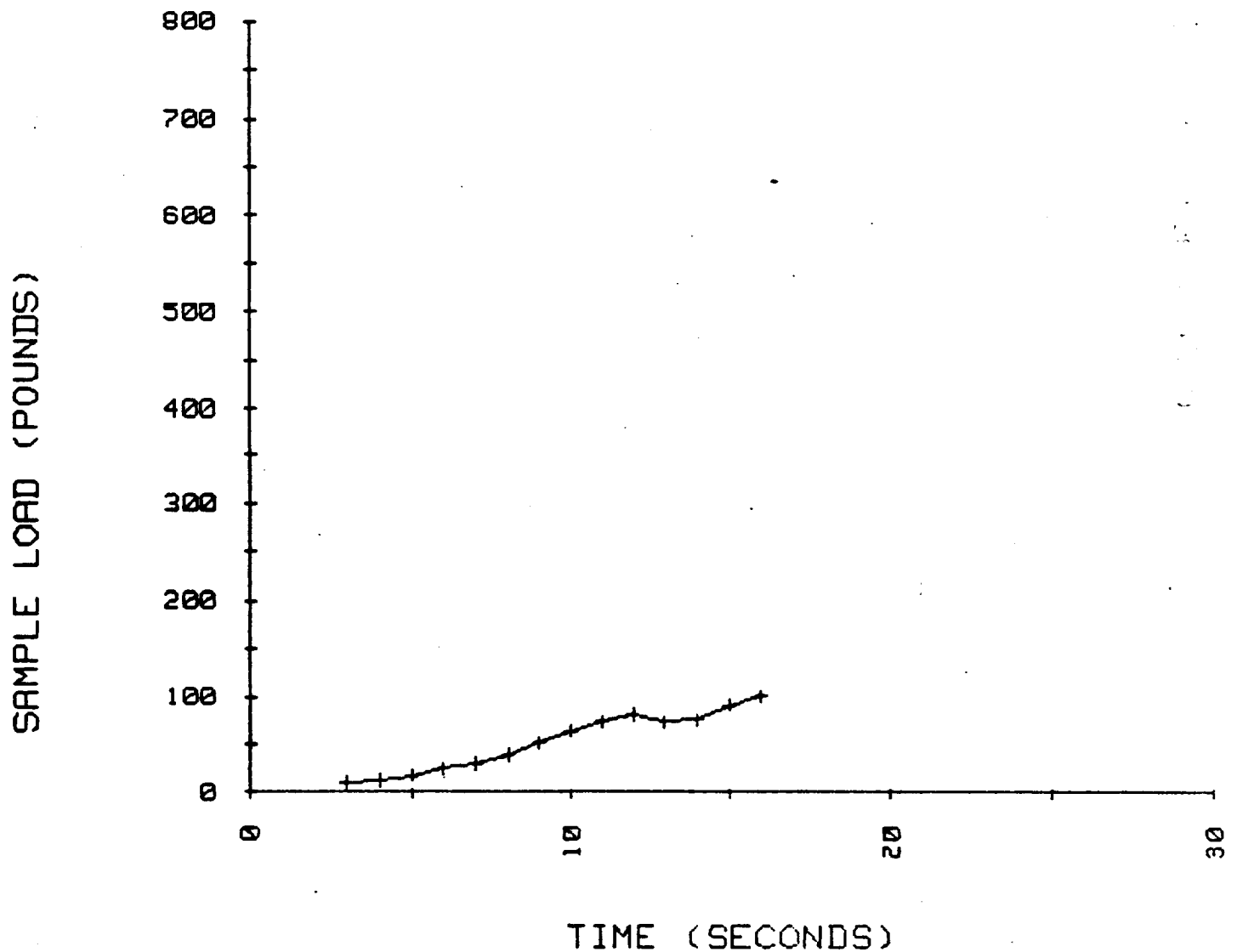
FRT #177



FRT #178

SAMPLES: SILICON CARBIDE
TEST RESULTS: SHATTER

SPEED: 9000 RPM (35 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (25 PSI/SEC)

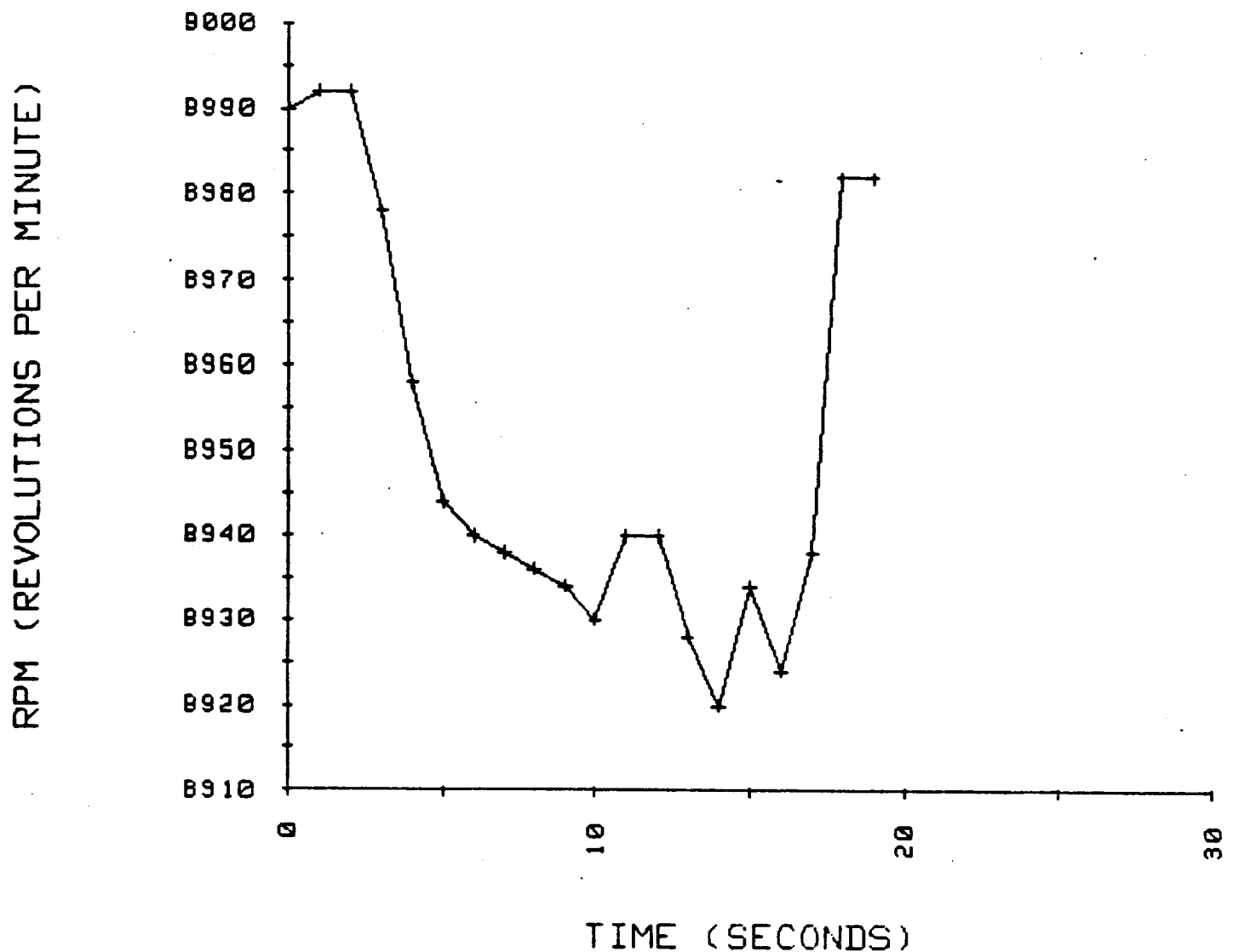


D-147

FRT #178

SAMPLES: SILICON CARBIDE
TEST RESULTS: SHATTER

SPEED: 9000 RPM (35 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (25 PSI/SEC)



FRT #178

SAMPLES: SILICON CARBIDE

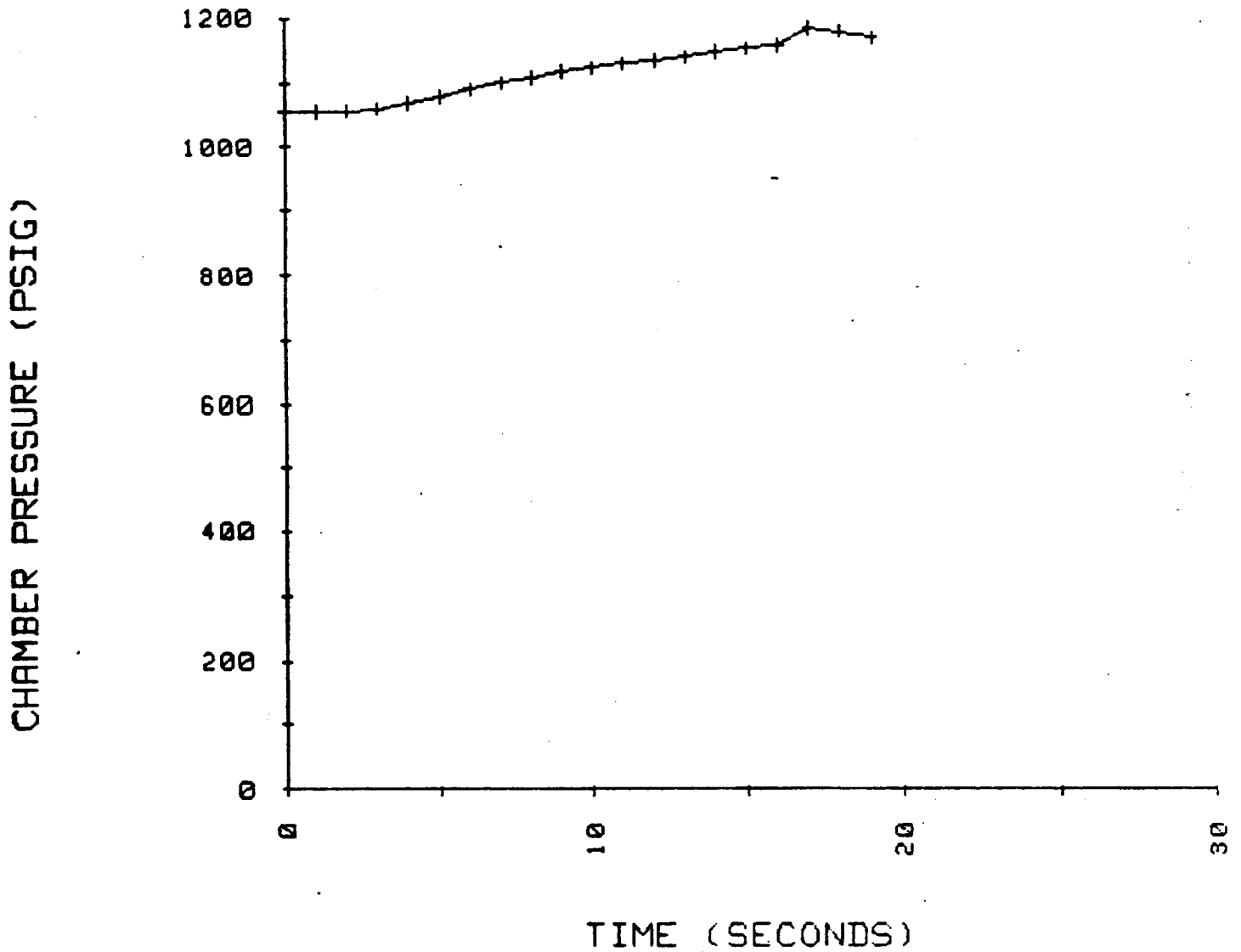
TEST RESULTS: SHATTER

SPEED: 9000 RPM (35 FT/SEC)

PRESS: 1000 PSIG

TYPE OF LOAD: INCREASING

LOAD RATE: 7 LB/SEC (25 PSI/SEC)



FRT #178

SAMPLES: SILICON CARBIDE

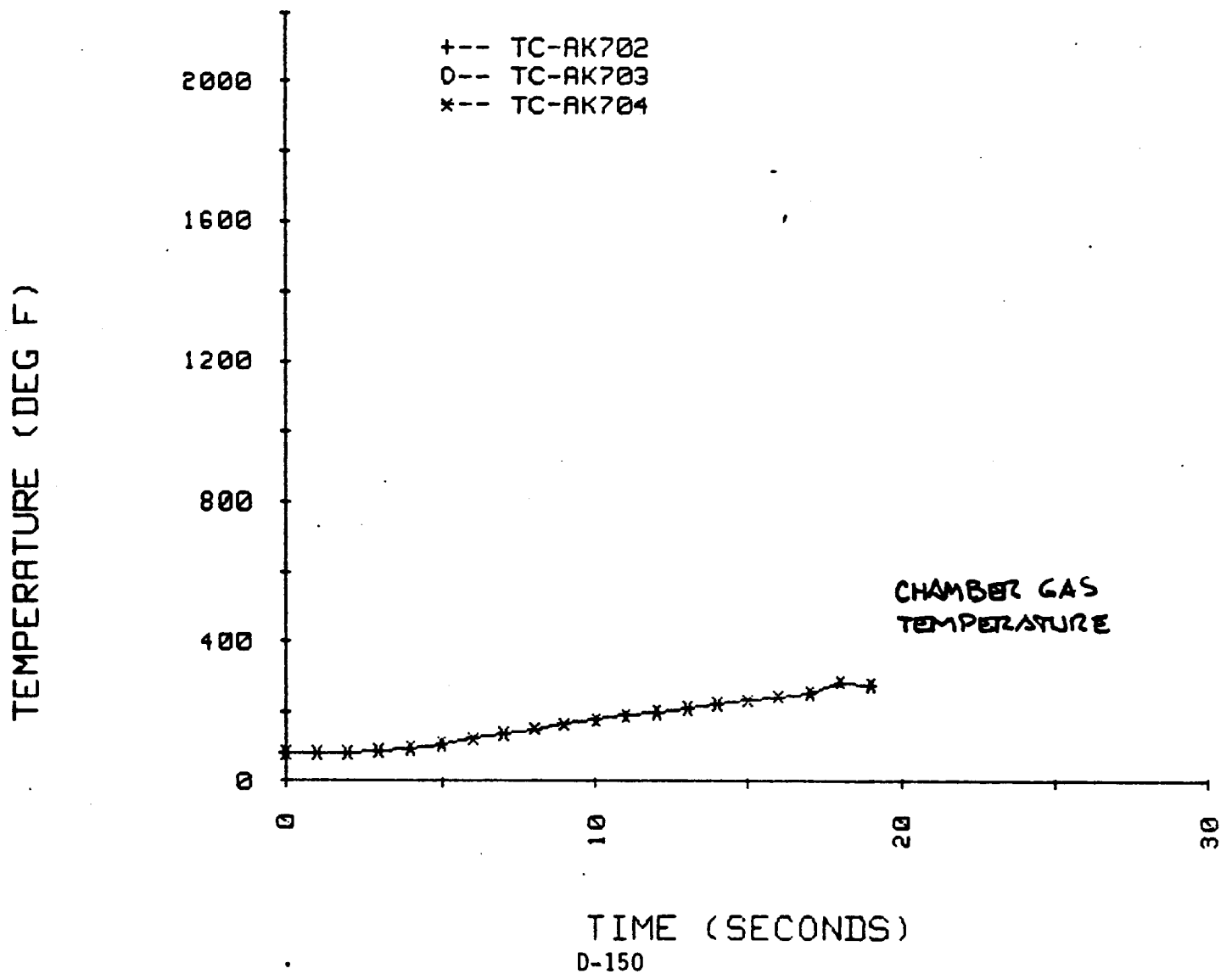
TEST RESULTS: SHATTER

SPEED: 9000 RPM (35 FT/SEC)

PRESS: 1000 PSIG

TYPE OF LOAD: INCREASING

LOAD RATE: 7 LB/SEC (25 PSI/SEC)



FRT #178

SAMPLES: SILICON CARBIDE

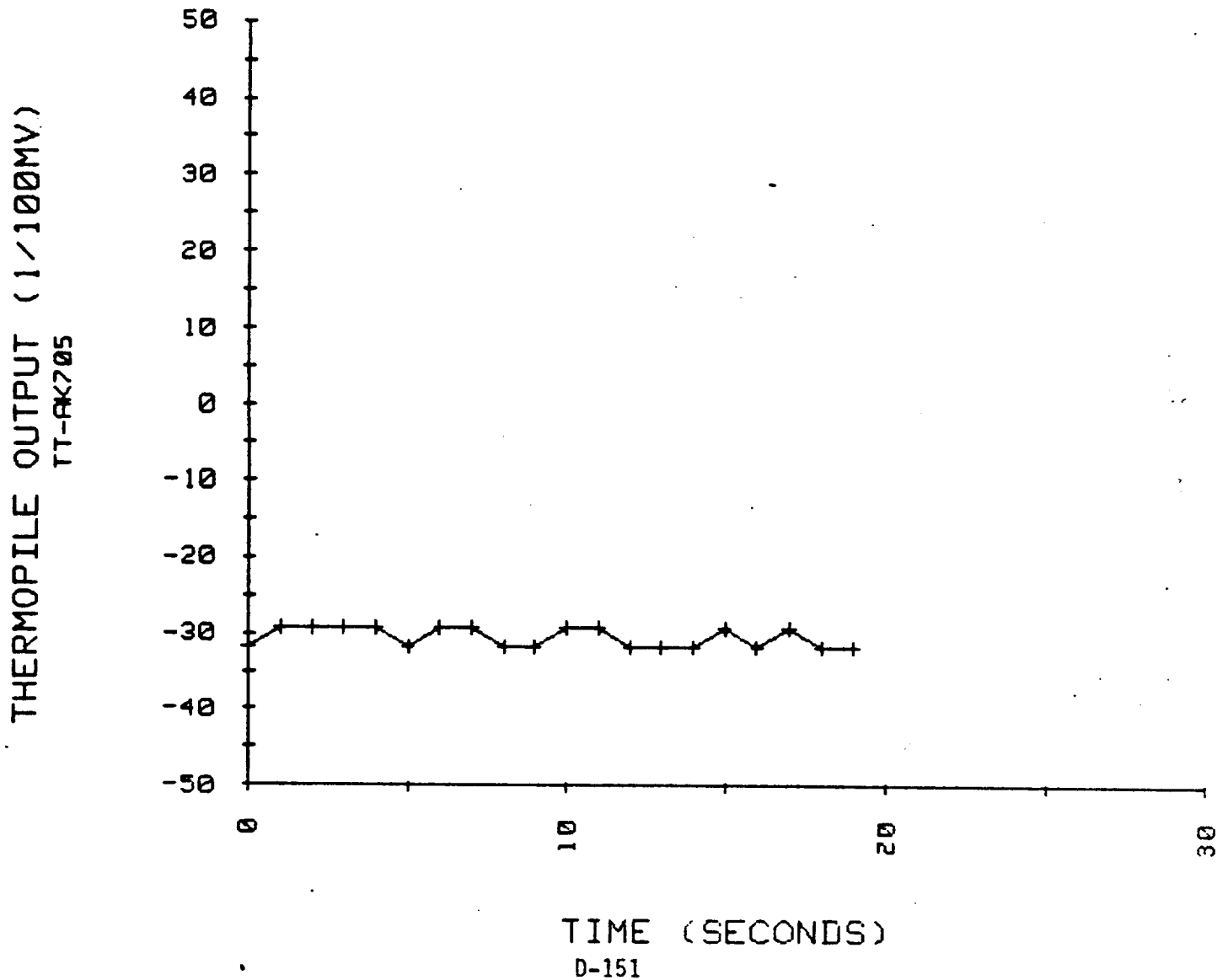
TEST RESULTS: SHATTER

SPEED: 9000 RPM (35 FT/SEC)

PRESS: 1000 PSIG

TYPE OF LOAD: INCREASING

LOAD RATE: 7 LB/SEC (25 PSI/SEC)



FRT #178

SAMPLES: SILICON CARBIDE

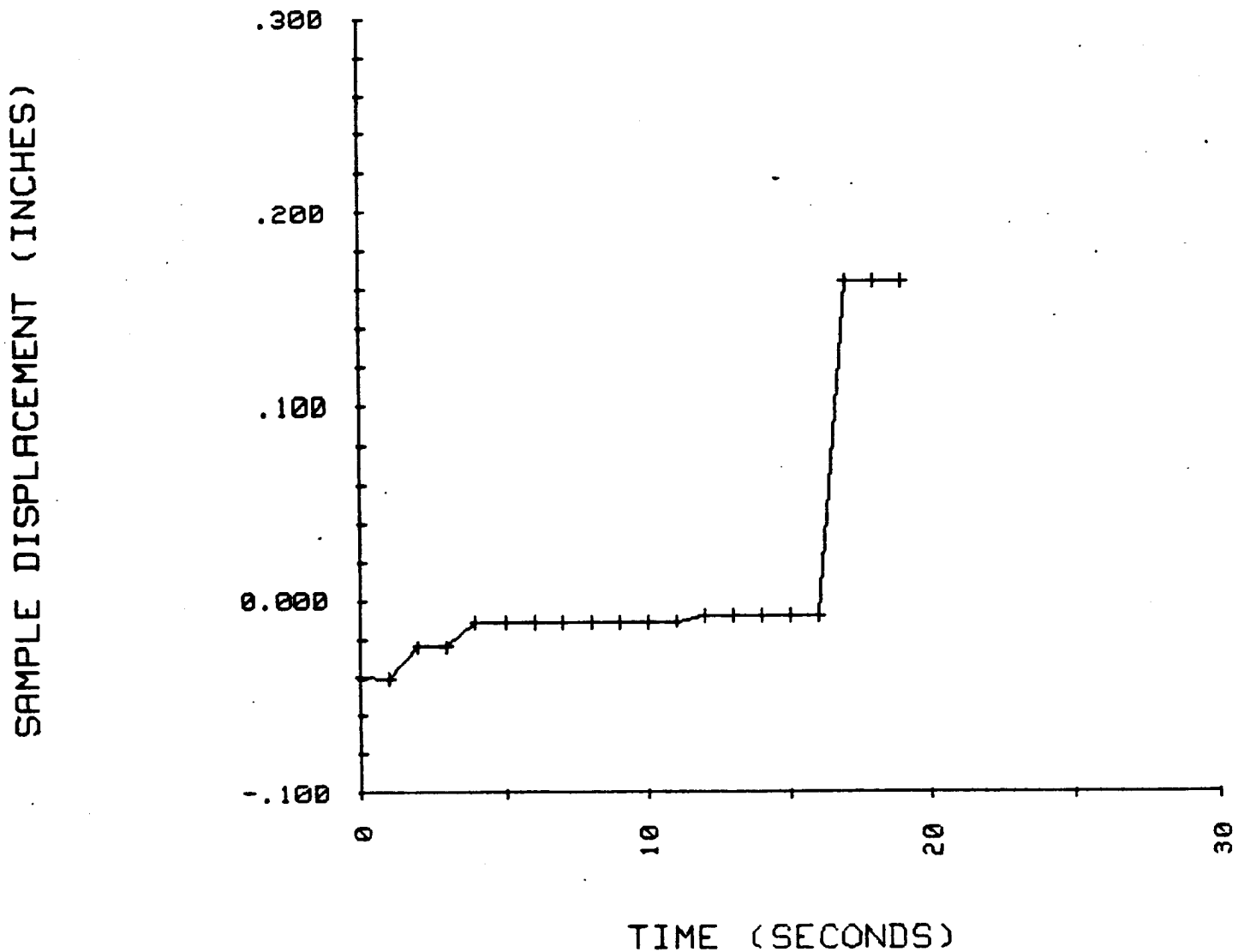
TEST RESULTS: SHATTER

SPEED: 9000 RPM (35 FT/SEC)

PRESS: 1000 PSIG

TYPE OF LOAD: INCREASING

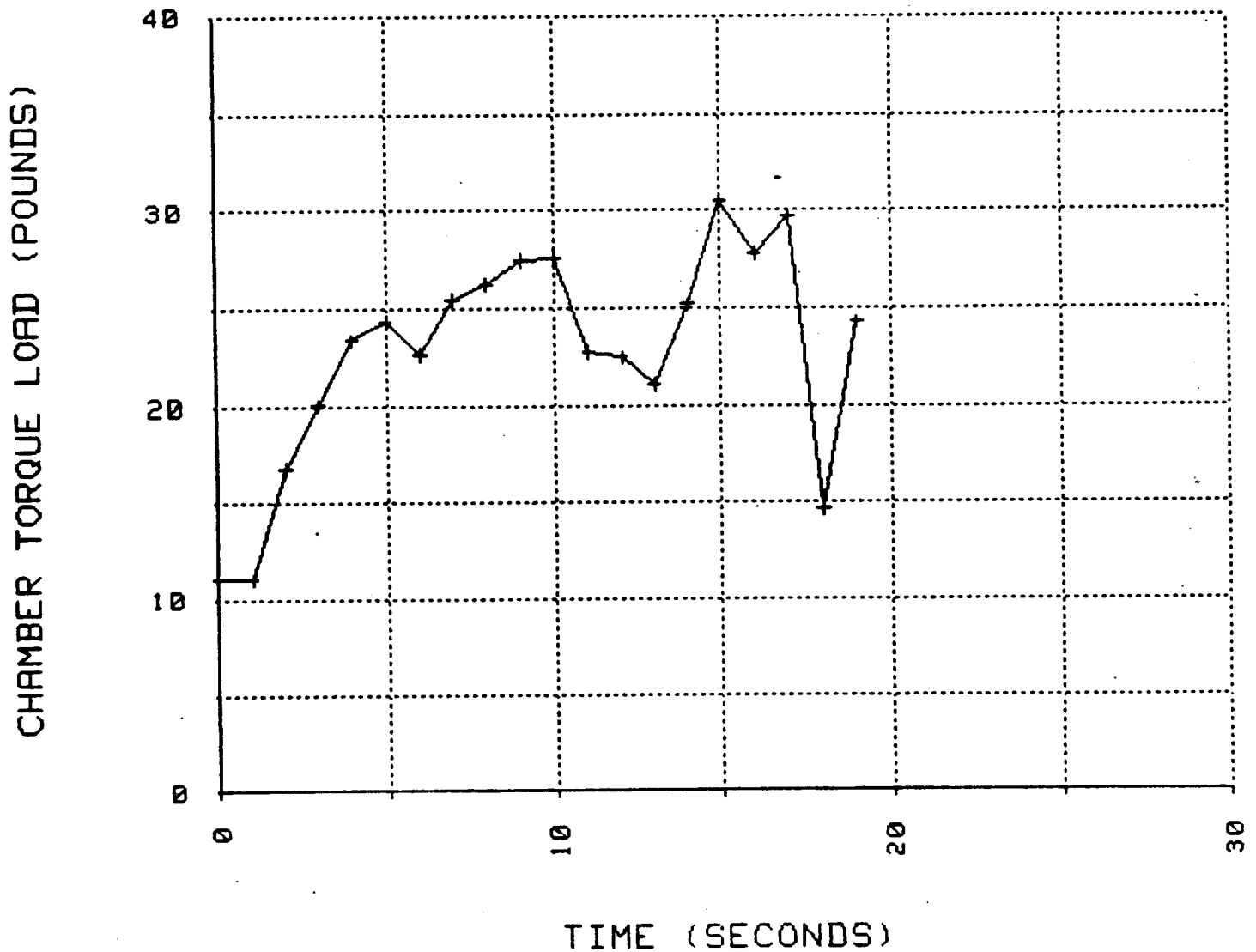
LOAD RATE: 7 LB/SEC (25 PSI/SEC)



FRT #178

SAMPLES: SILICON CARBIDE
TEST RESULTS: SHATTER

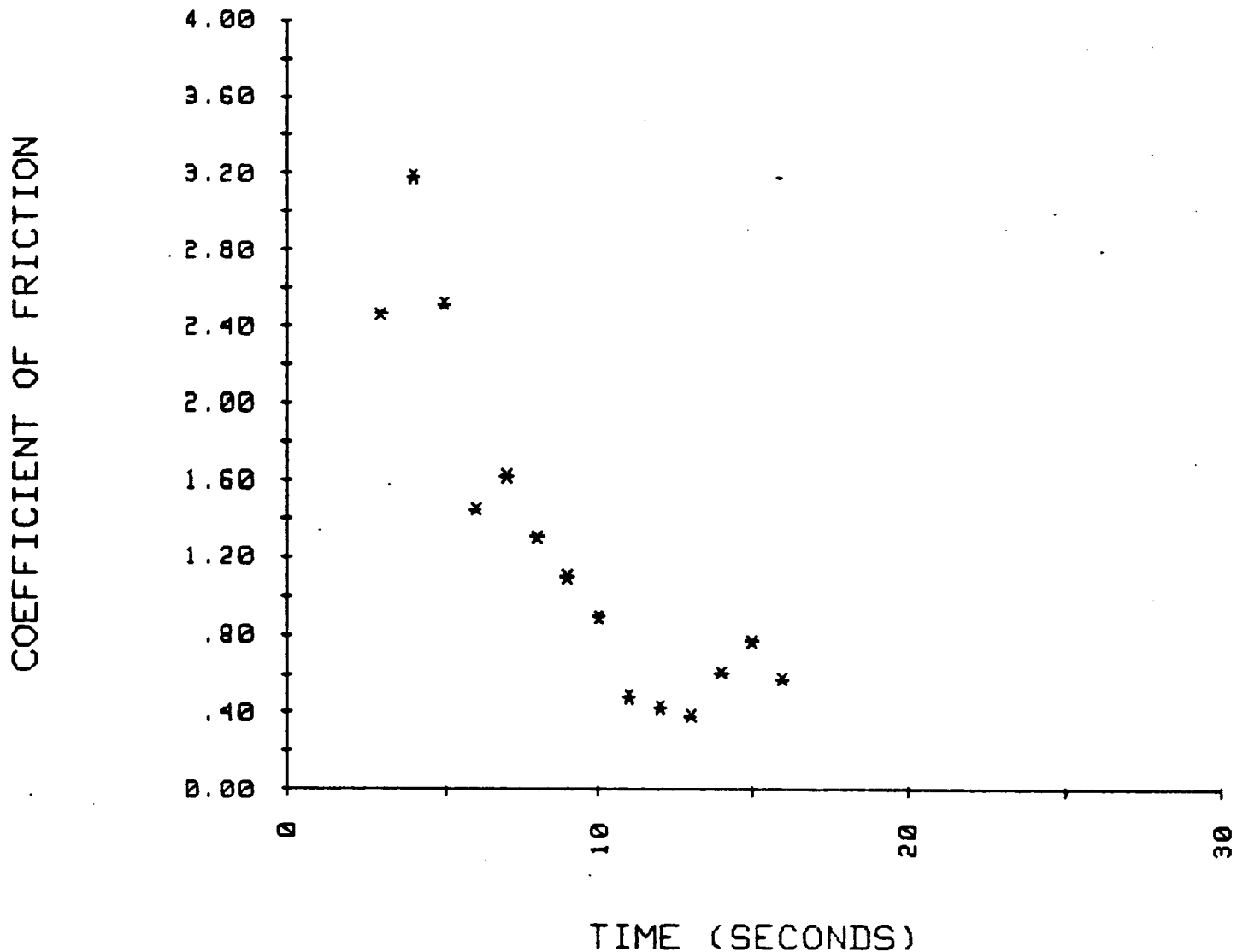
SPEED: 9000 RPM (35 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (25 PSI/SEC)



FRT #178

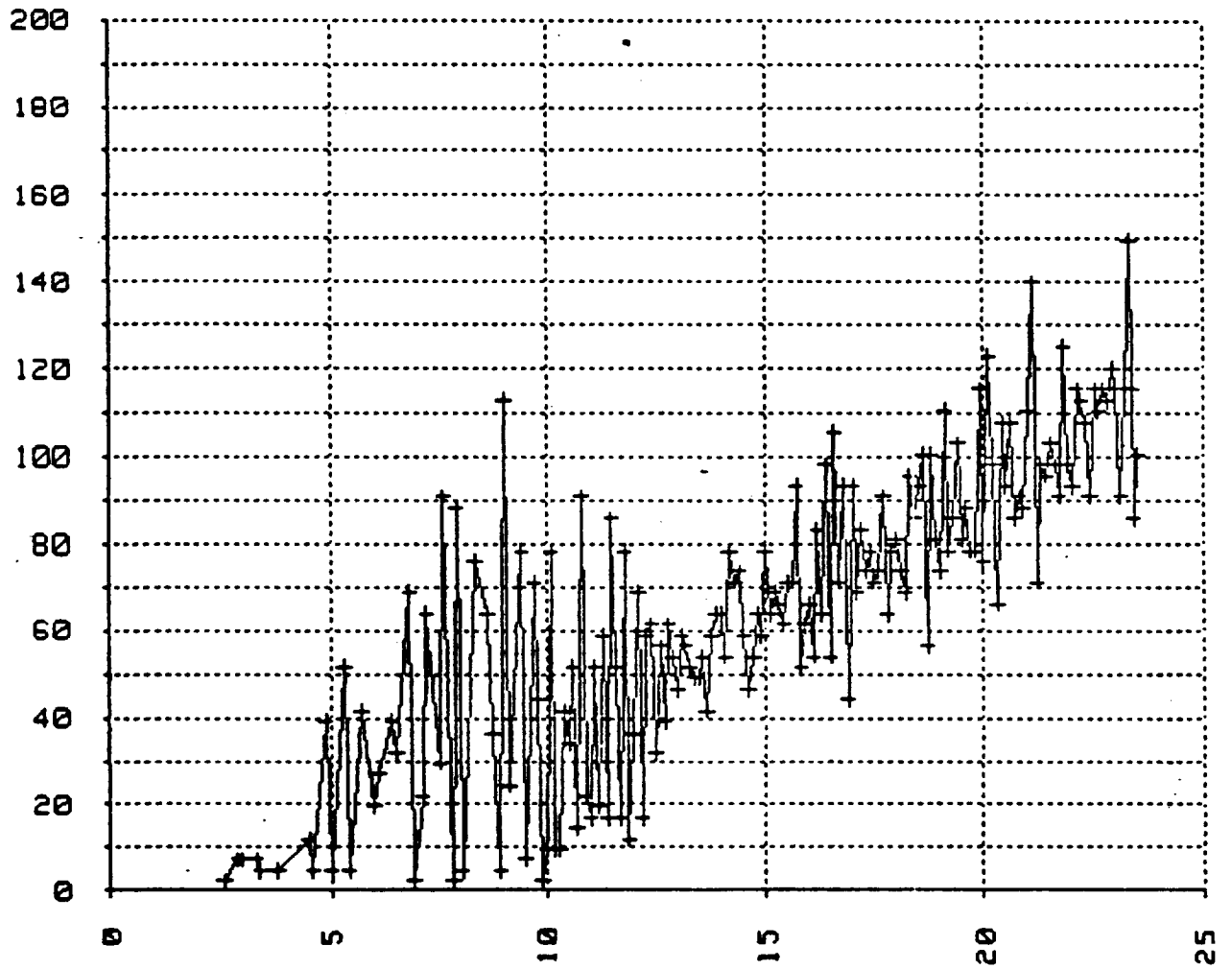
SAMPLES: SILICON CARBIDE
TEST RESULTS: SHATTER

SPEED: 9000 RPM (35 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (25 PSI/SEC)



SAMPLE LOAD (POUNDS)

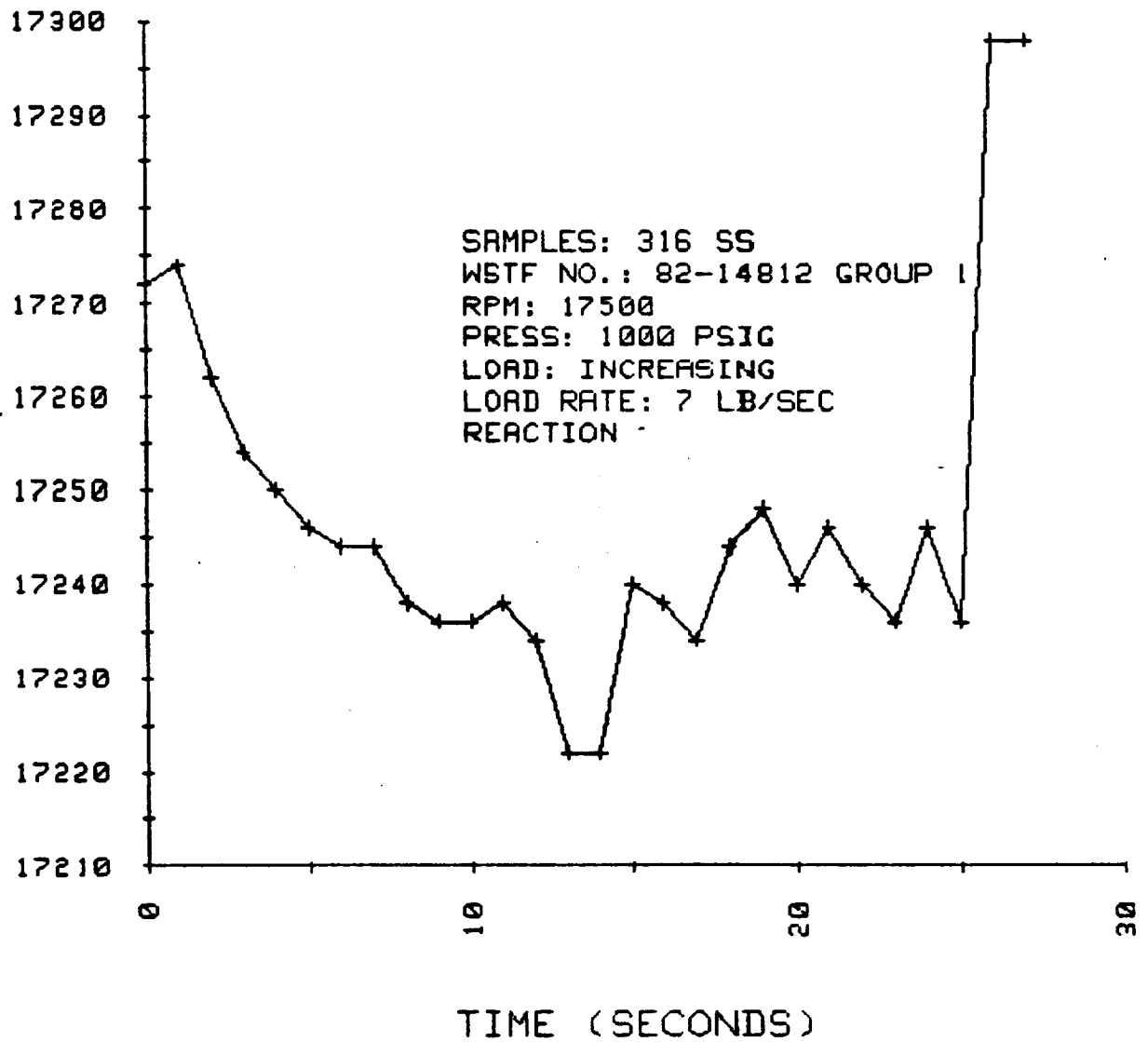
FRT #140



TIME (SECONDS)

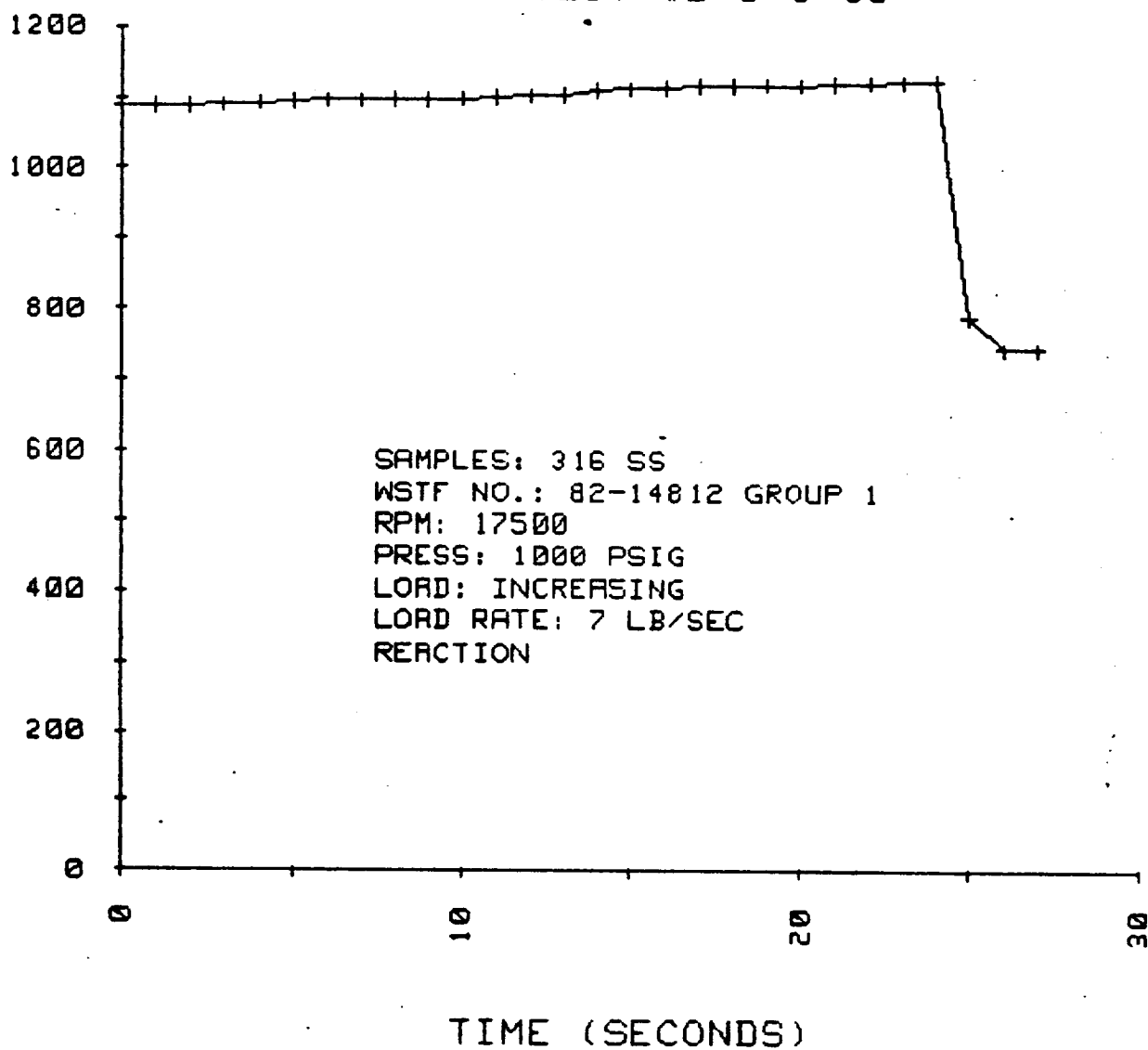
FRT #140 TEST #2 6/8/83

RPM (REVOLUTIONS PER MINUTE)



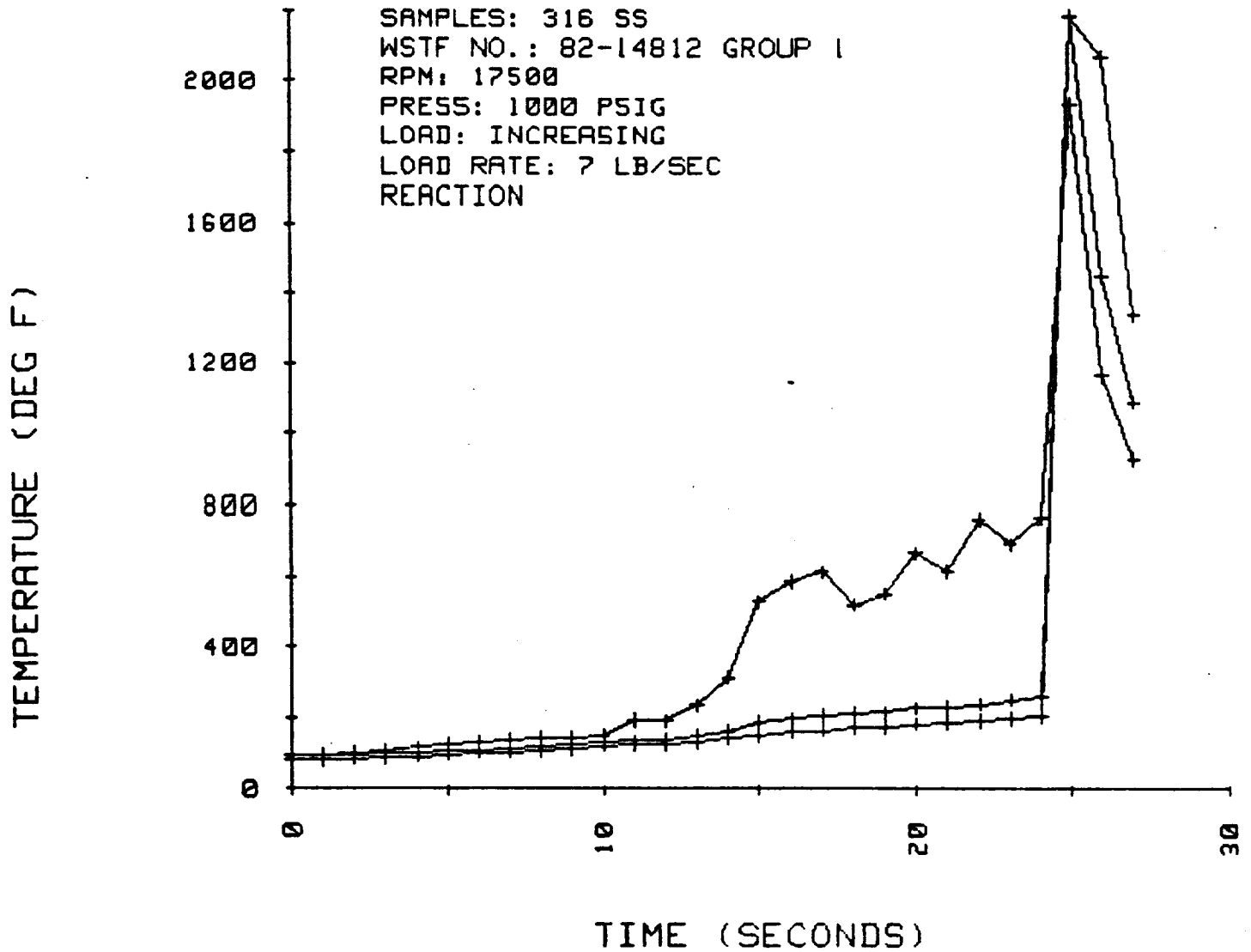
CHAMBER PRESSURE (PSIG)

FRT #140 TEST #2 6/8/83



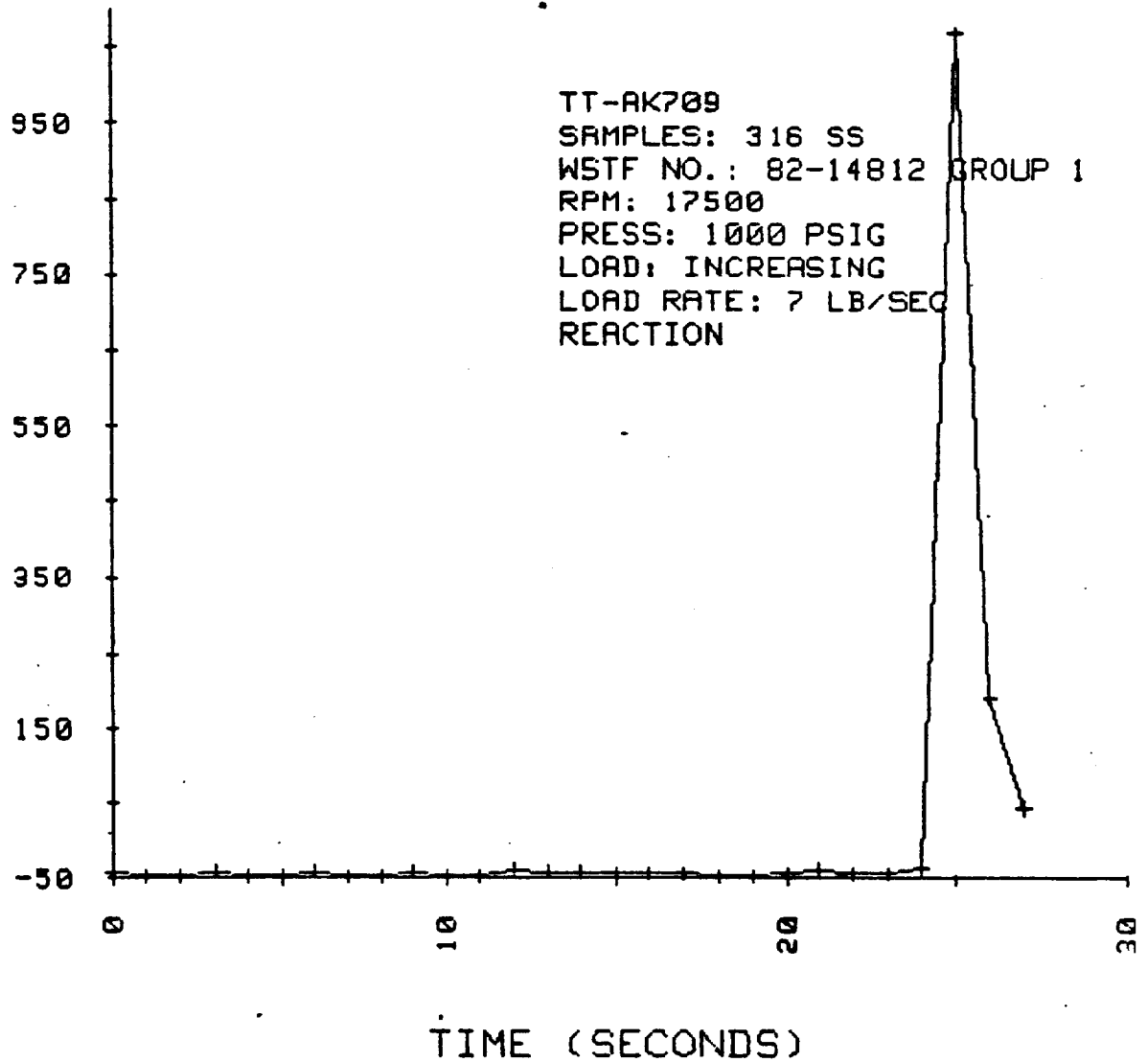
FRT #140 TEST #2 6/8/83

SAMPLES: 316 SS
WSTF NO.: 82-14812 GROUP 1
RPM: 17500
PRESS: 1000 PSIG
LOAD: INCREASING
LOAD RATE: 7 LB/SEC
REACTION



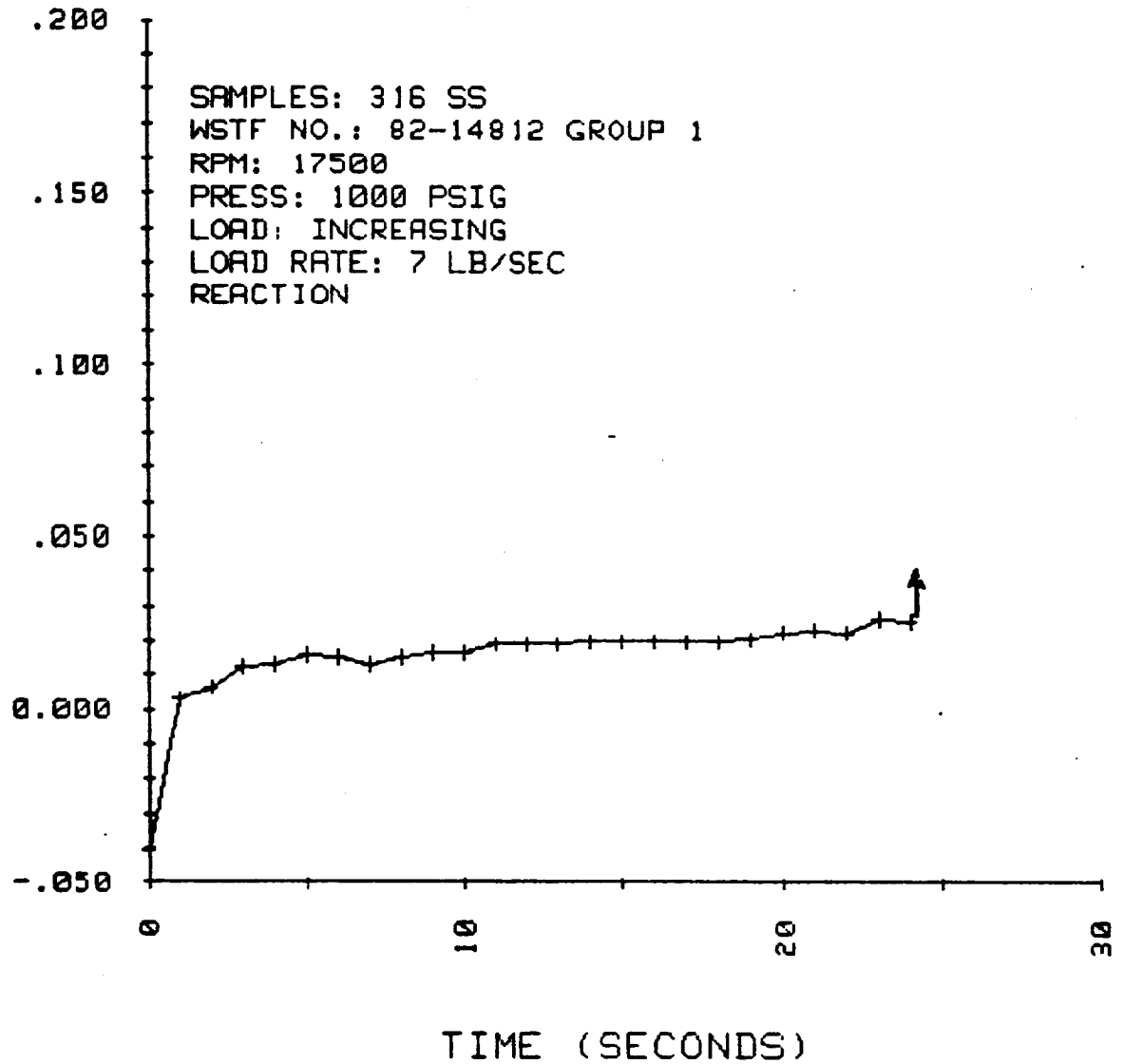
FRT #140 TEST #2 6/8/83

THERMOPILE OUTPUT (1/100MV)

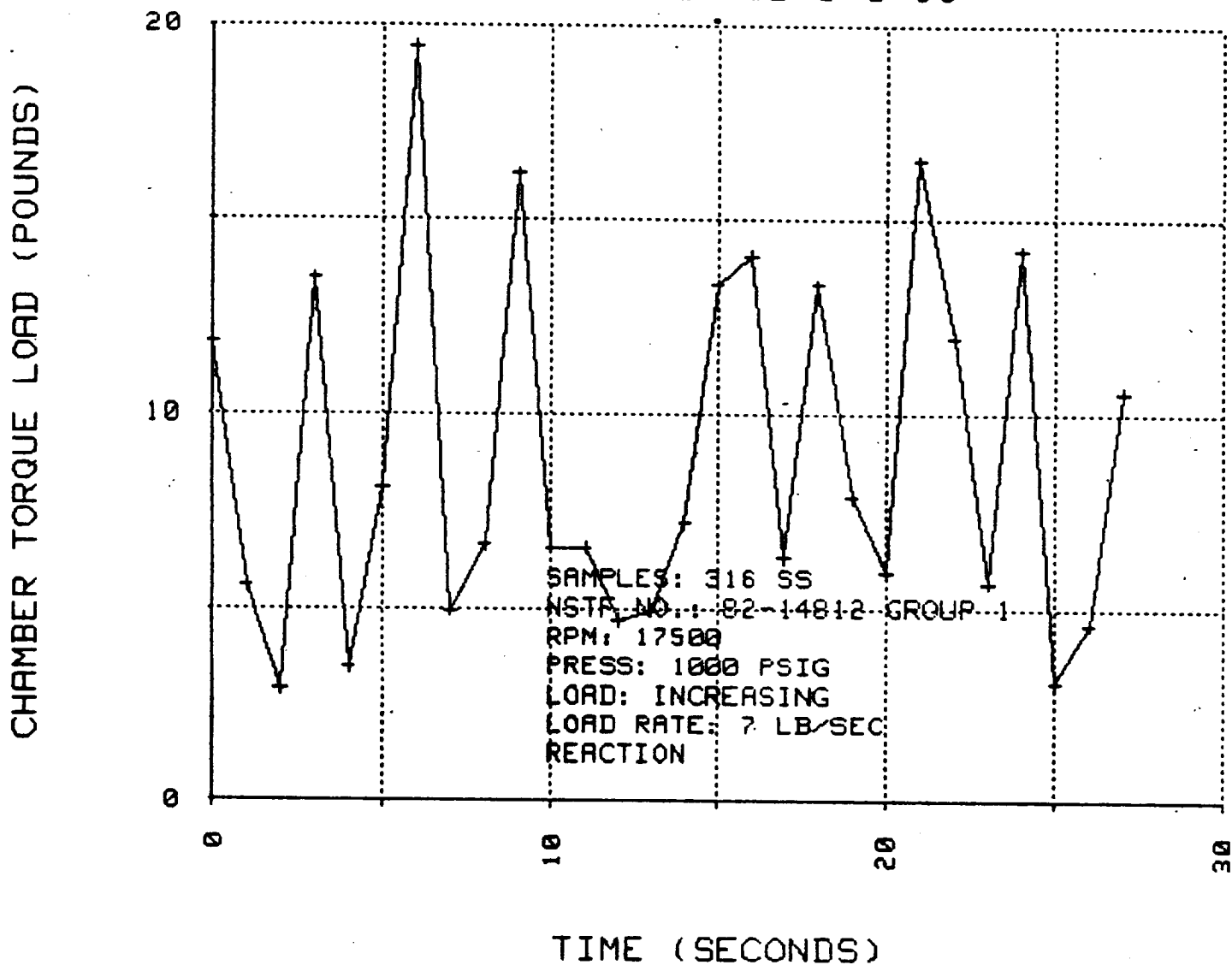


FRT #140 TEST #2 6/8/83

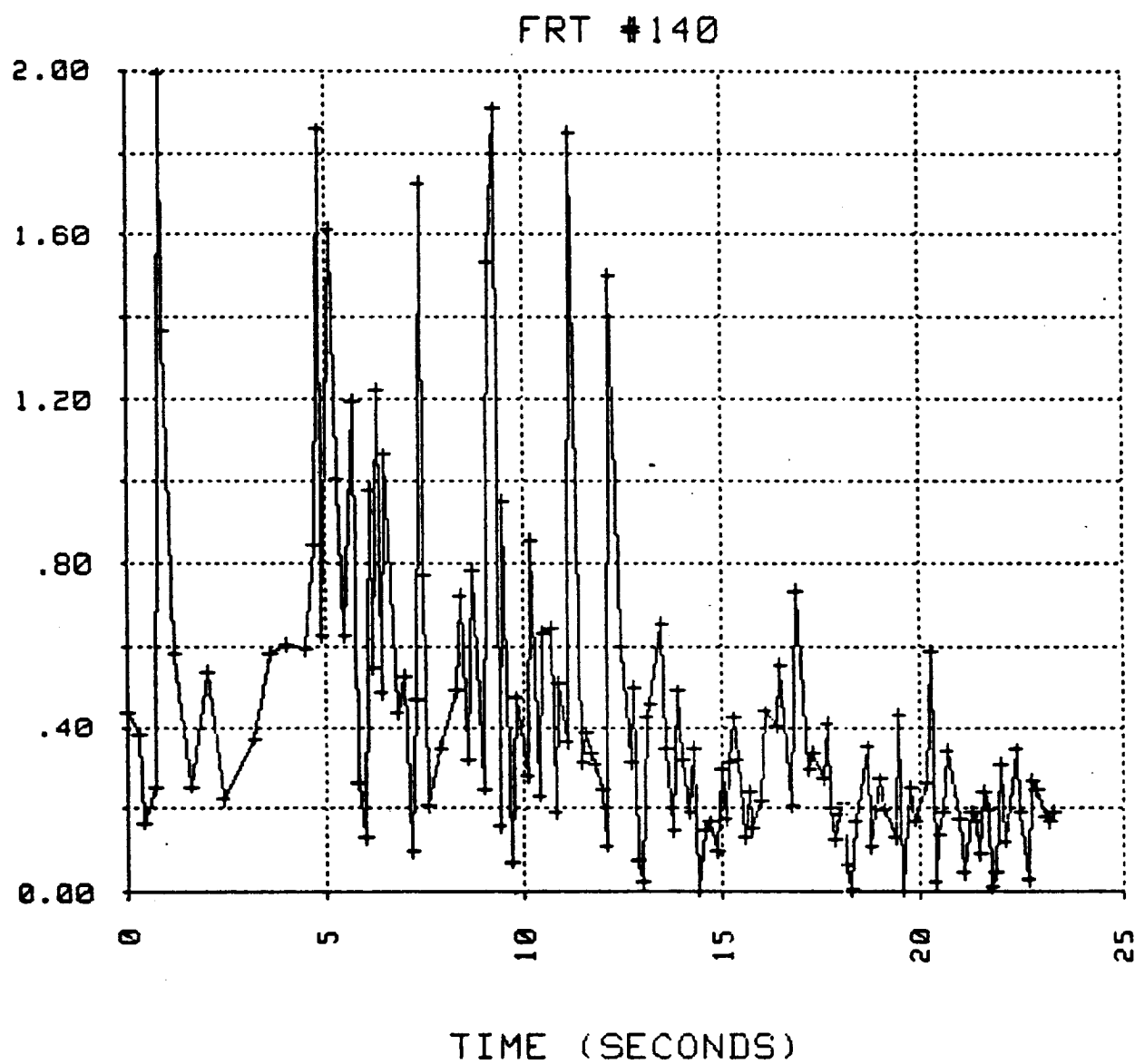
SAMPLE DISPLACEMENT (INCHES)



FRT #140 TEST #2 6/8/83

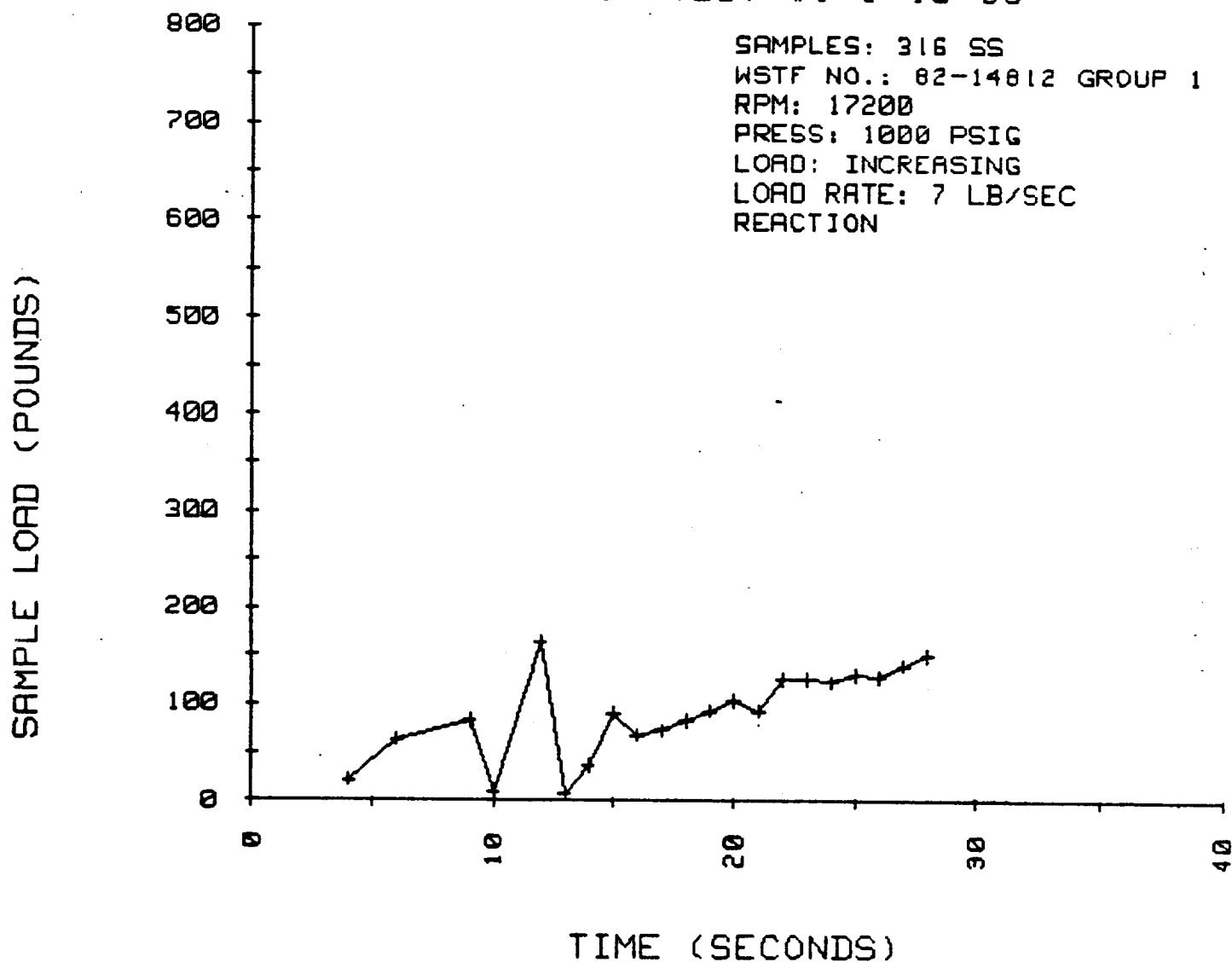


COEFFICIENT OF FRICTION

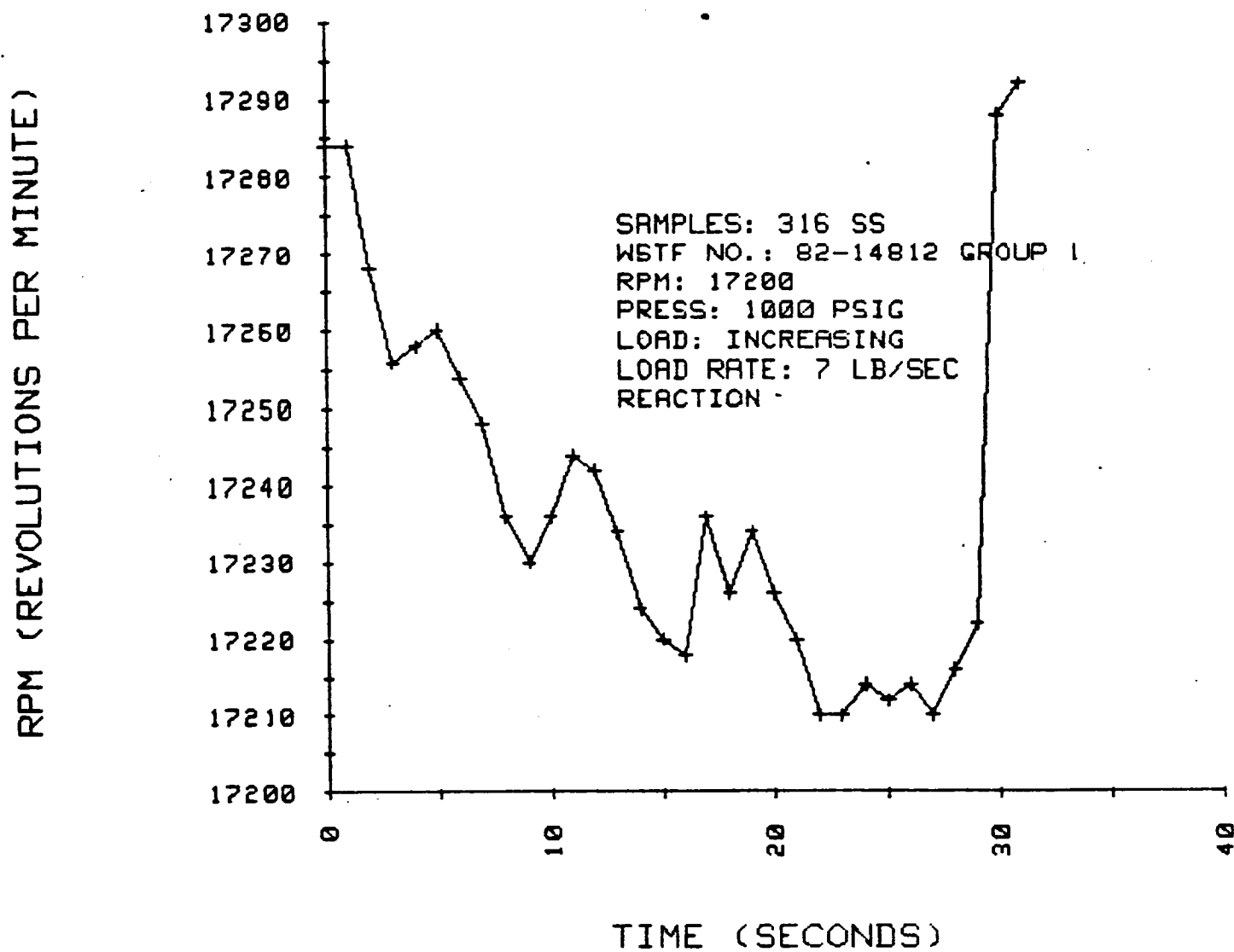


FRT #141 TEST #1 6/10/83

SAMPLES: 316 SS
WSTF NO.: 82-14812 GROUP 1
RPM: 17200
PRESS: 1000 PSIG
LOAD: INCREASING
LOAD RATE: 7 LB/SEC
REACTION

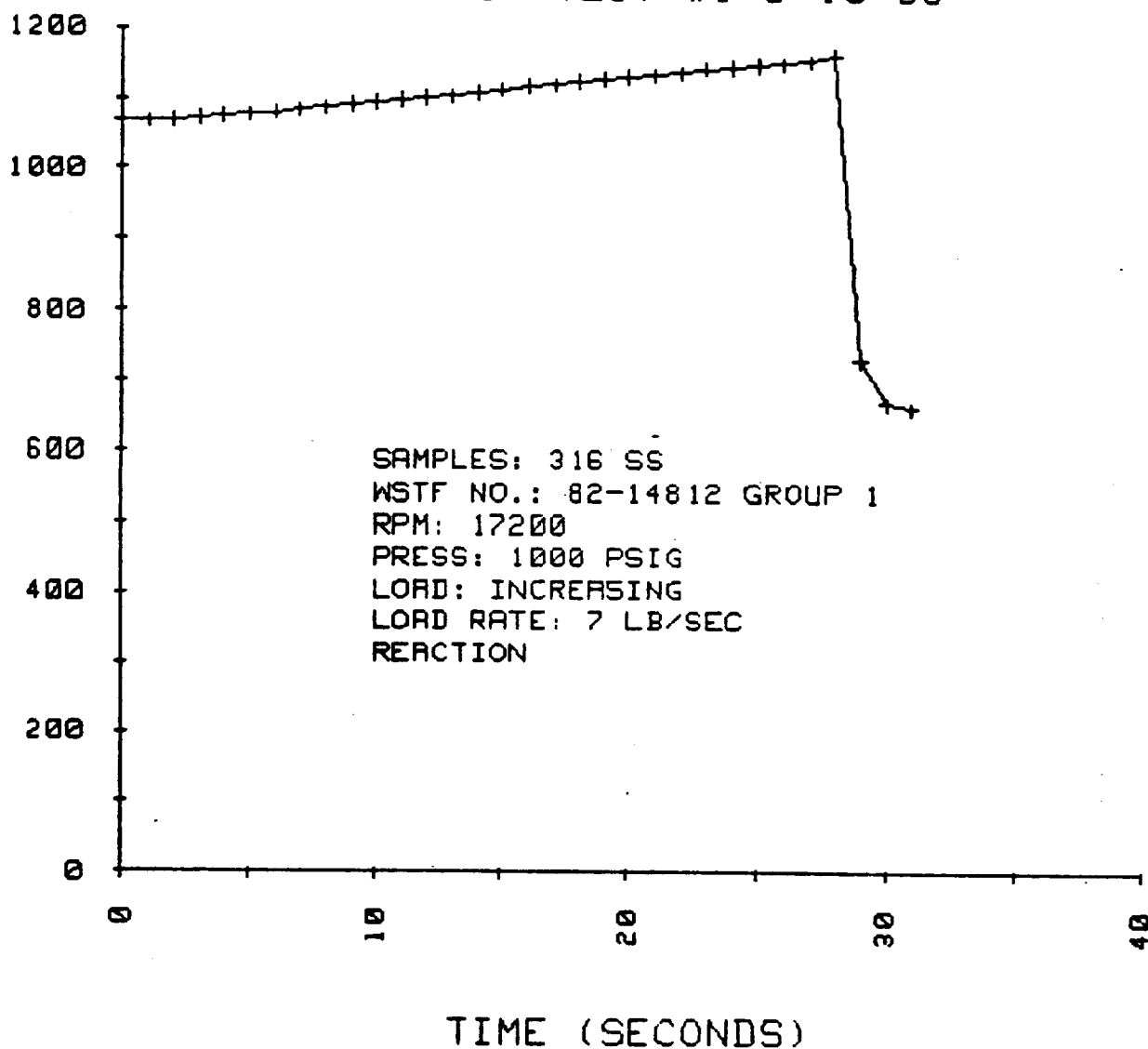


FRT #141 TEST #1 6/10/83



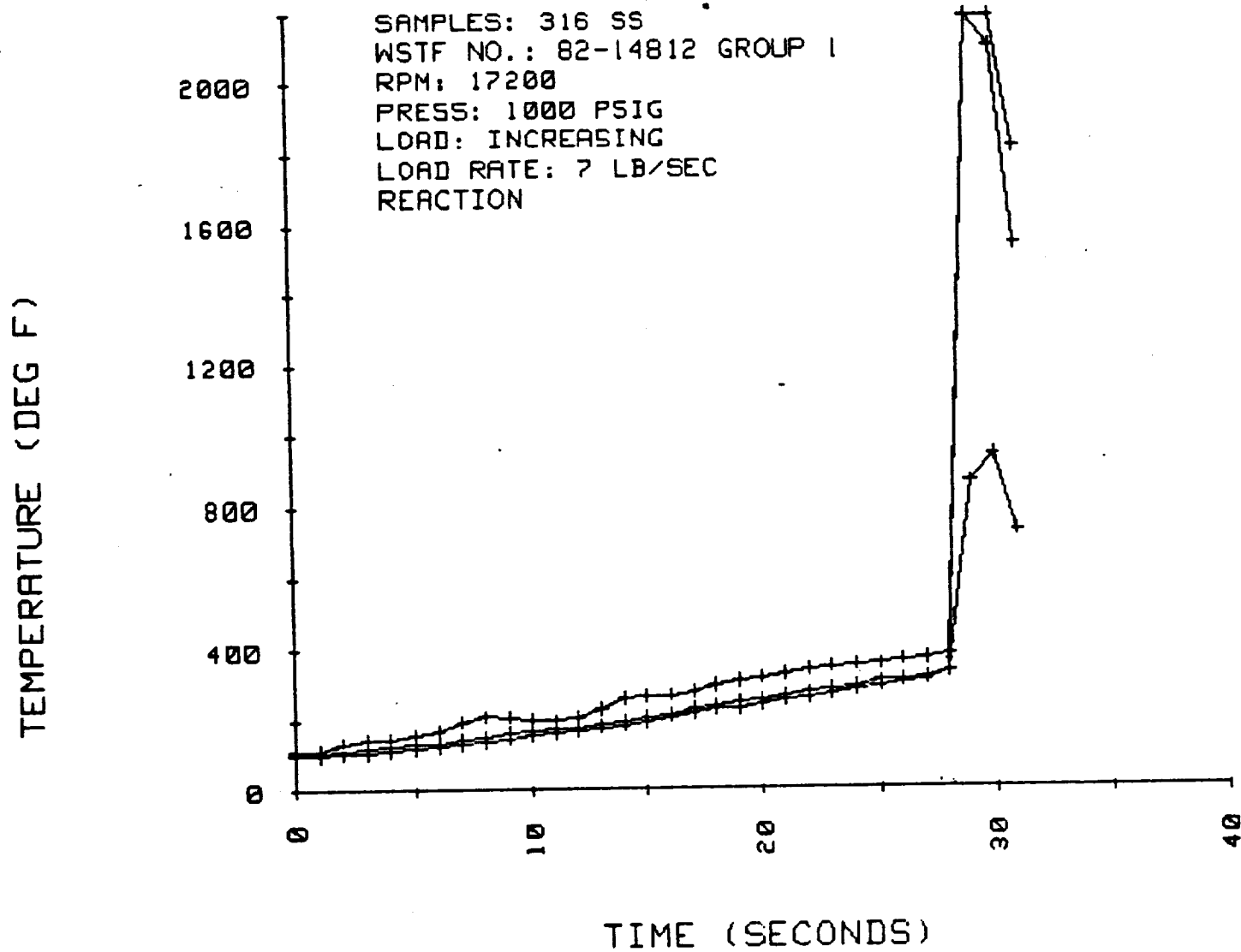
CHAMBER PRESSURE (PSIG)

FRT #141 TEST #1 6/10/83



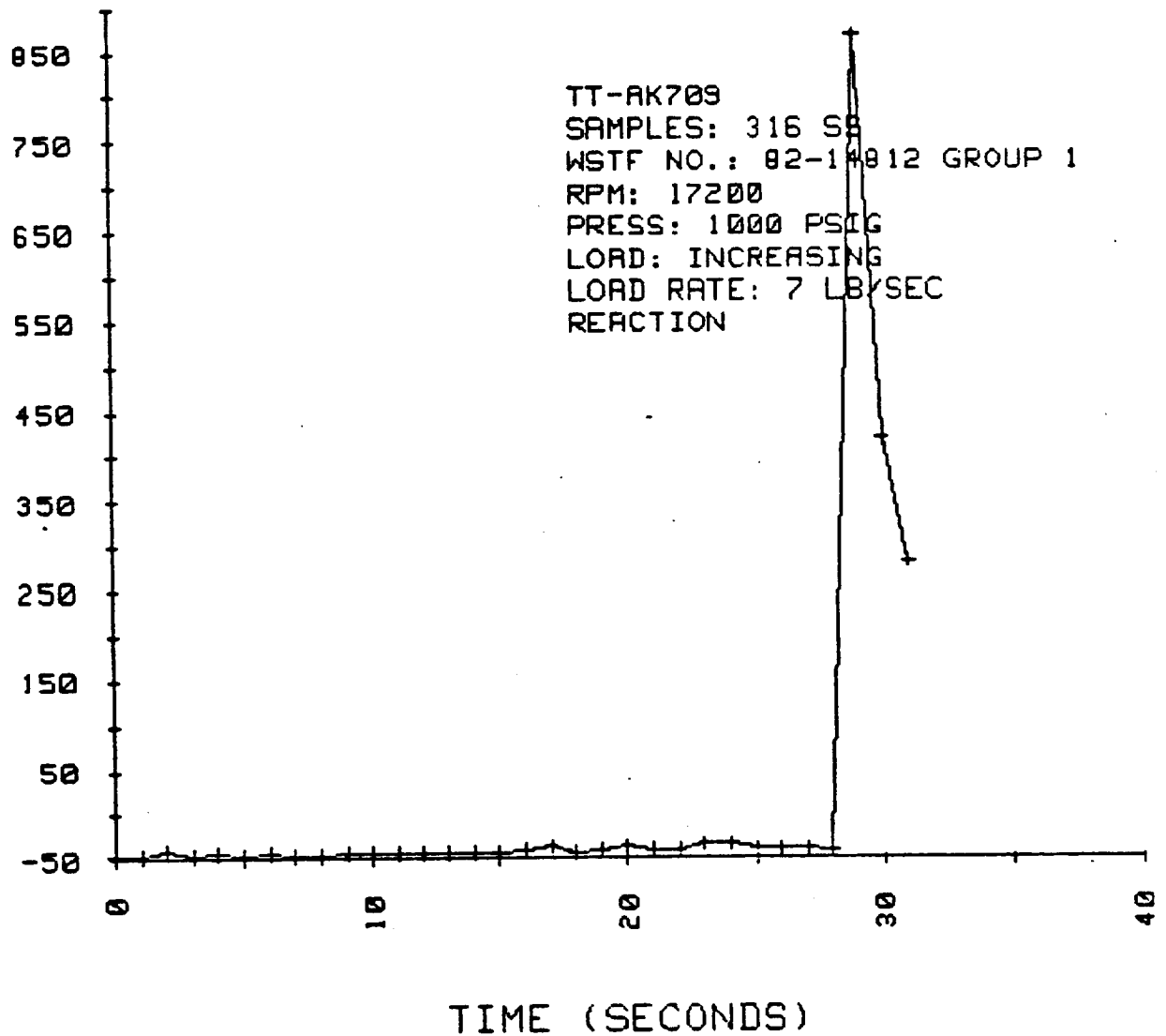
FRT #141 TEST #1 6/10/83

SAMPLES: 316 SS
 WSTF NO.: 82-14812 GROUP 1
 RPM: 17200
 PRESS: 1000 PSIG
 LOAD: INCREASING
 LOAD RATE: 7 LB/SEC
 REACTION



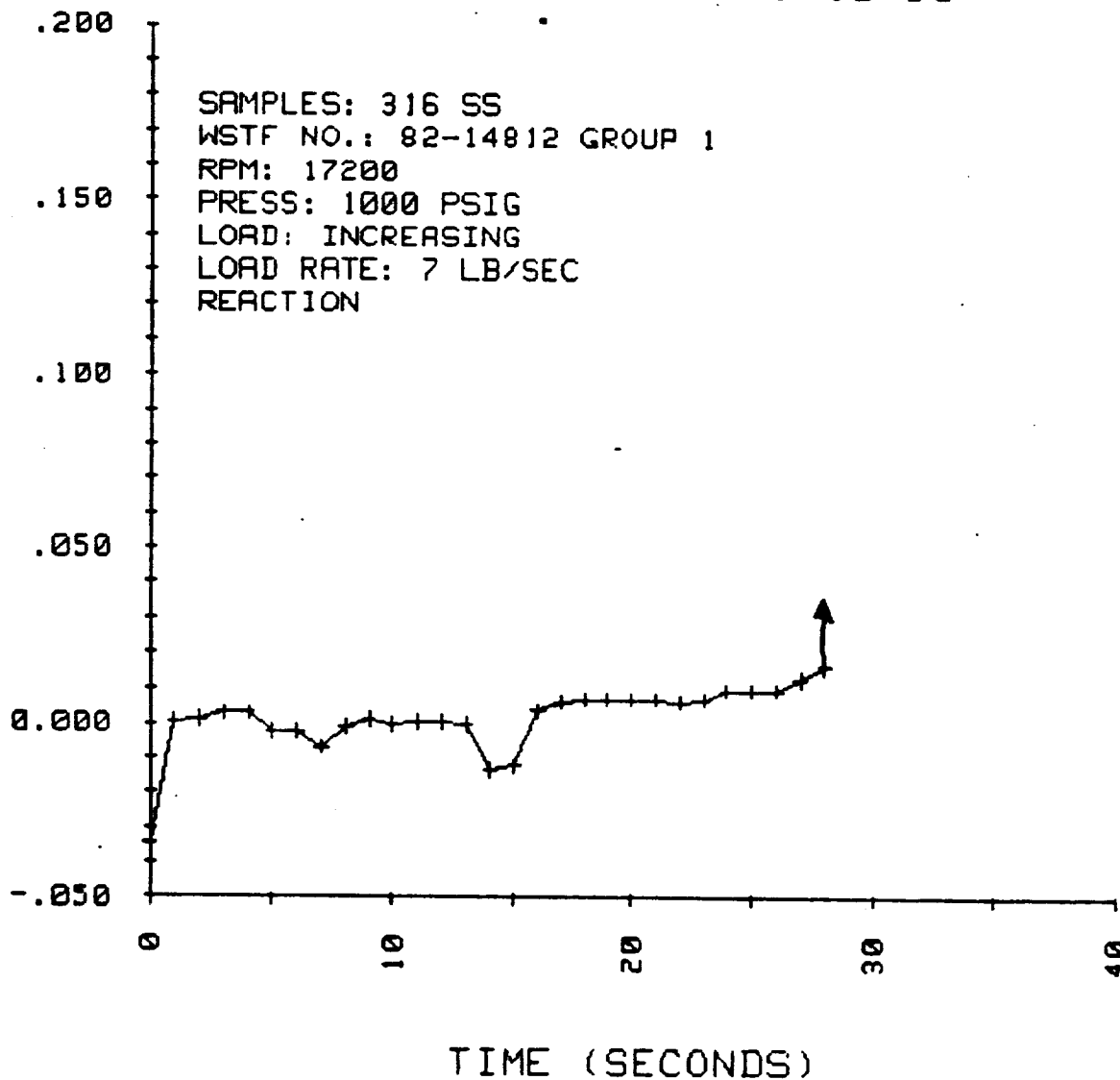
FRT #141 TEST #1 6/10/83

THERMOPILE OUTPUT (1/100MV)



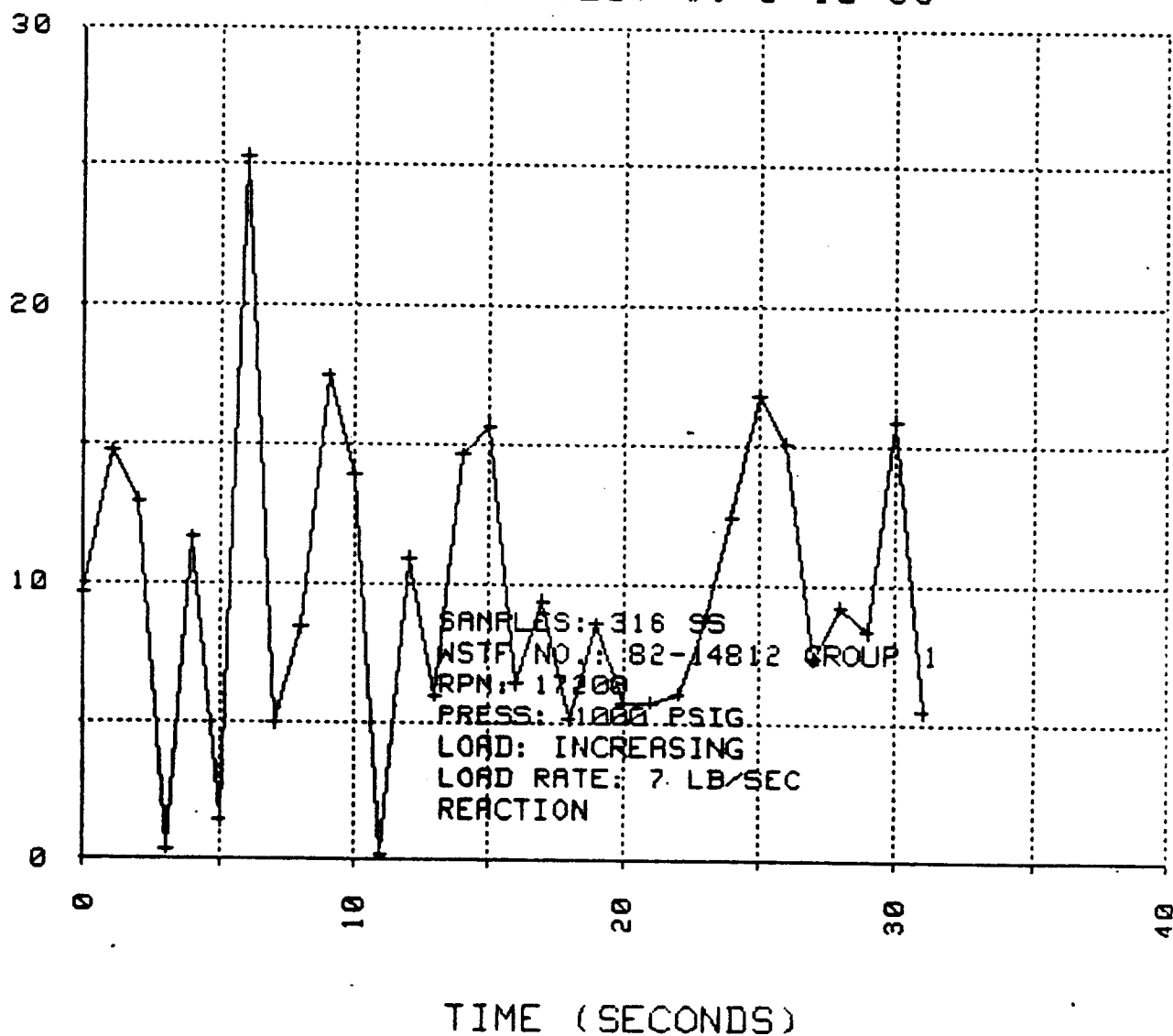
SAMPLE DISPLACEMENT (INCHES)

FRT #141 TEST #1 6/10/83

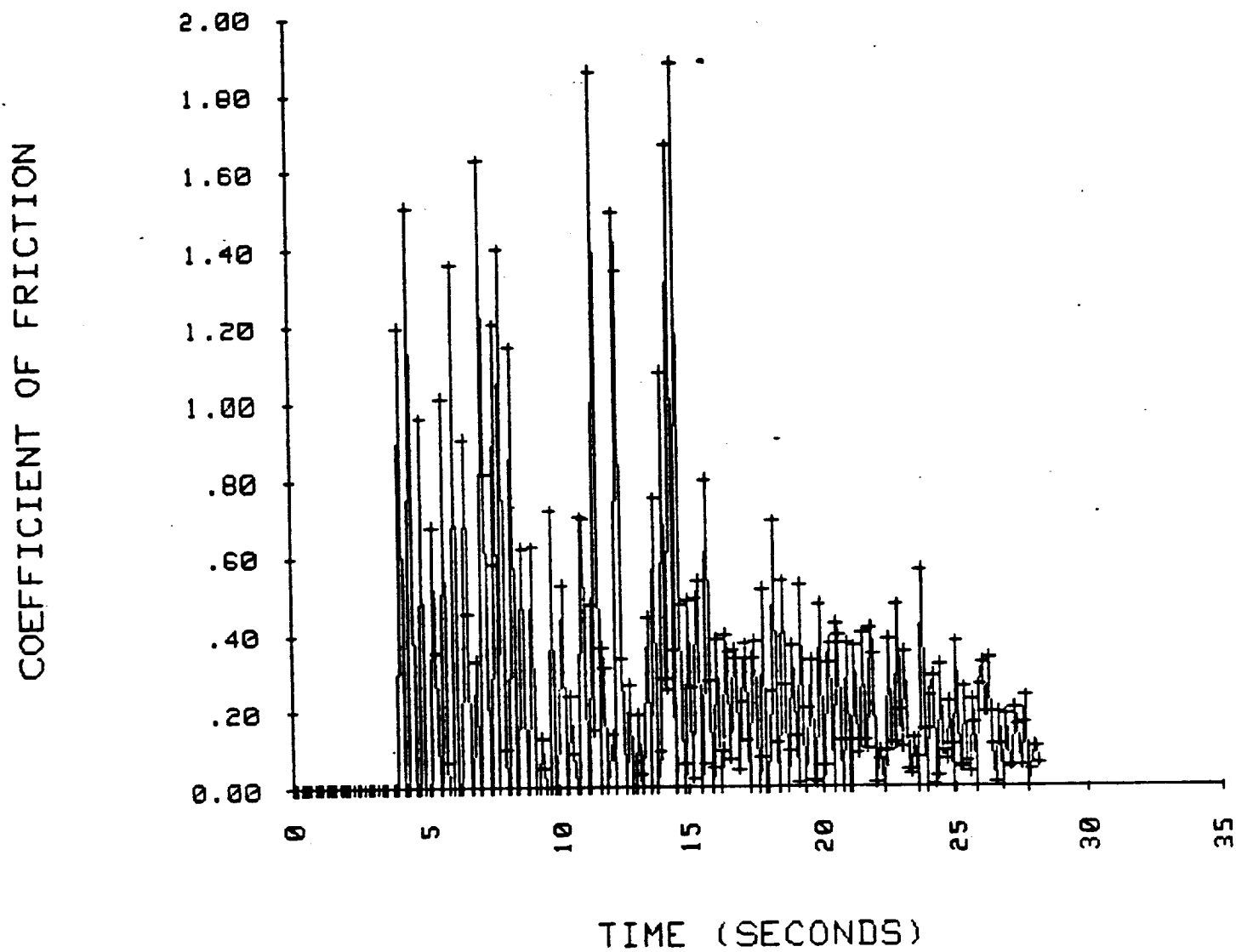


FRT #141 TEST #1 6/10/83

CHAMBER TORQUE LOAD (POUNDS)



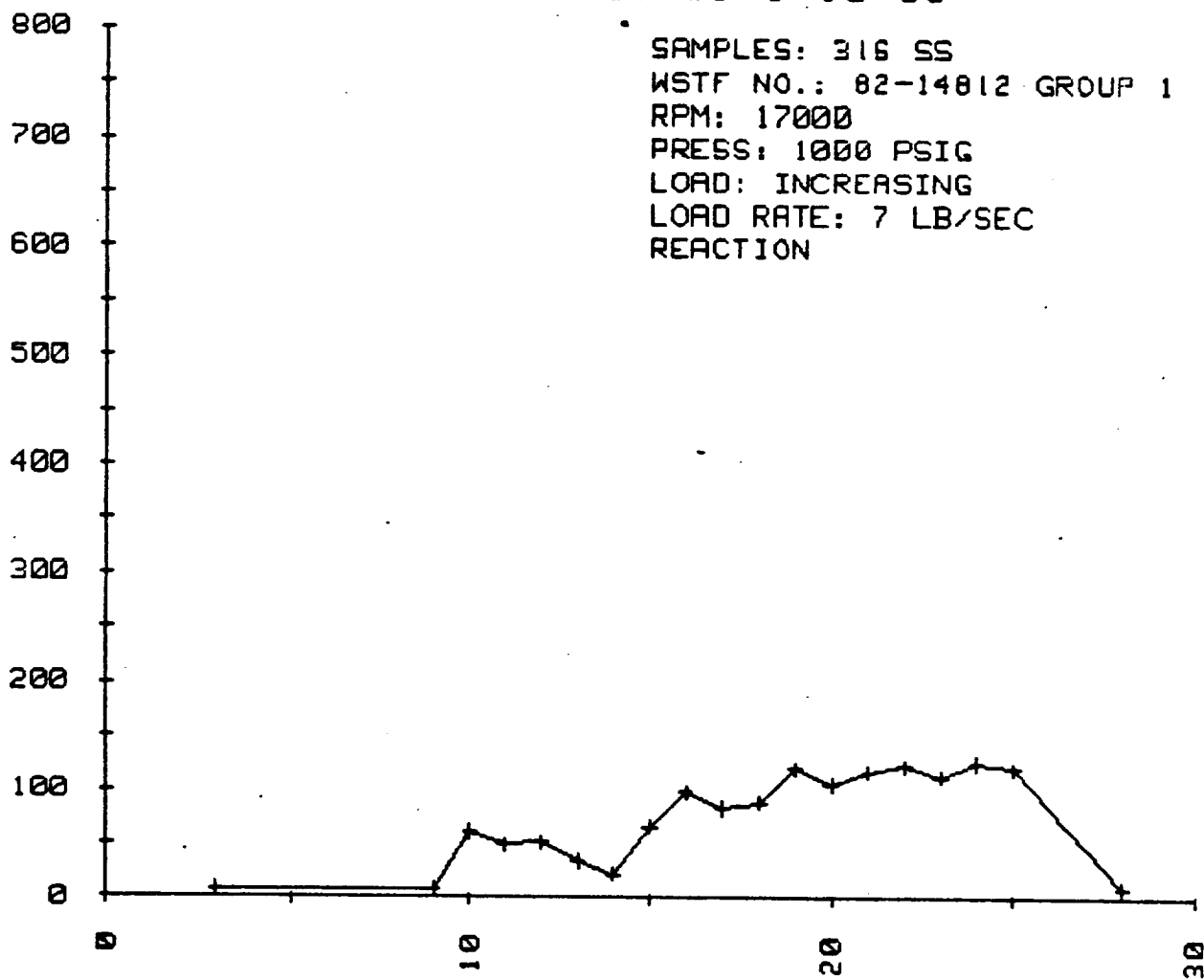
FRT #141 6/10/83



FRT #143 TEST #3 6/10/83

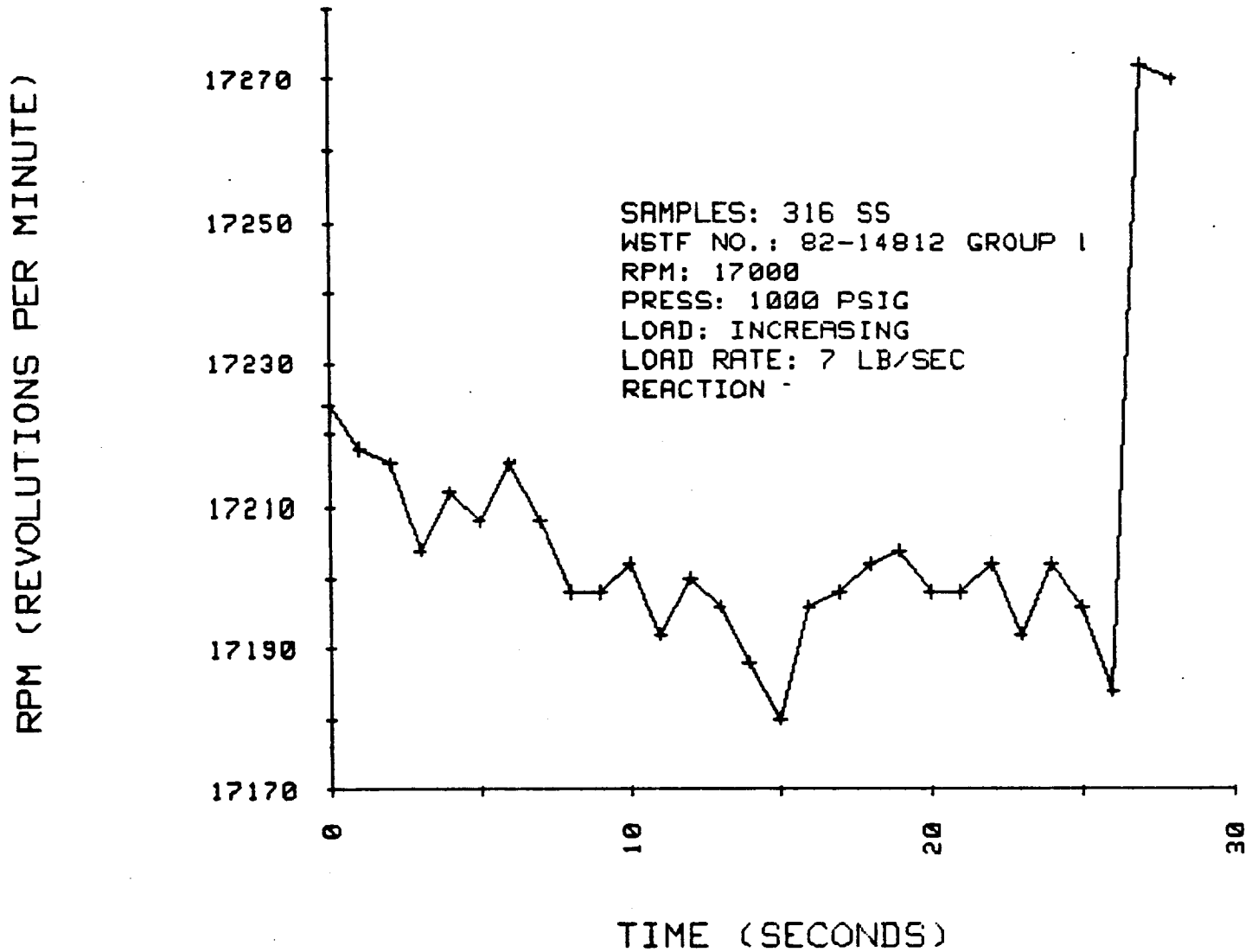
SAMPLES: 316 SS
WSTF NO.: 82-14812 GROUP 1
RPM: 17000
PRESS: 1000 PSIG
LOAD: INCREASING
LOAD RATE: 7 LB/SEC
REACTION

SAMPLE LOAD (POUNDS)



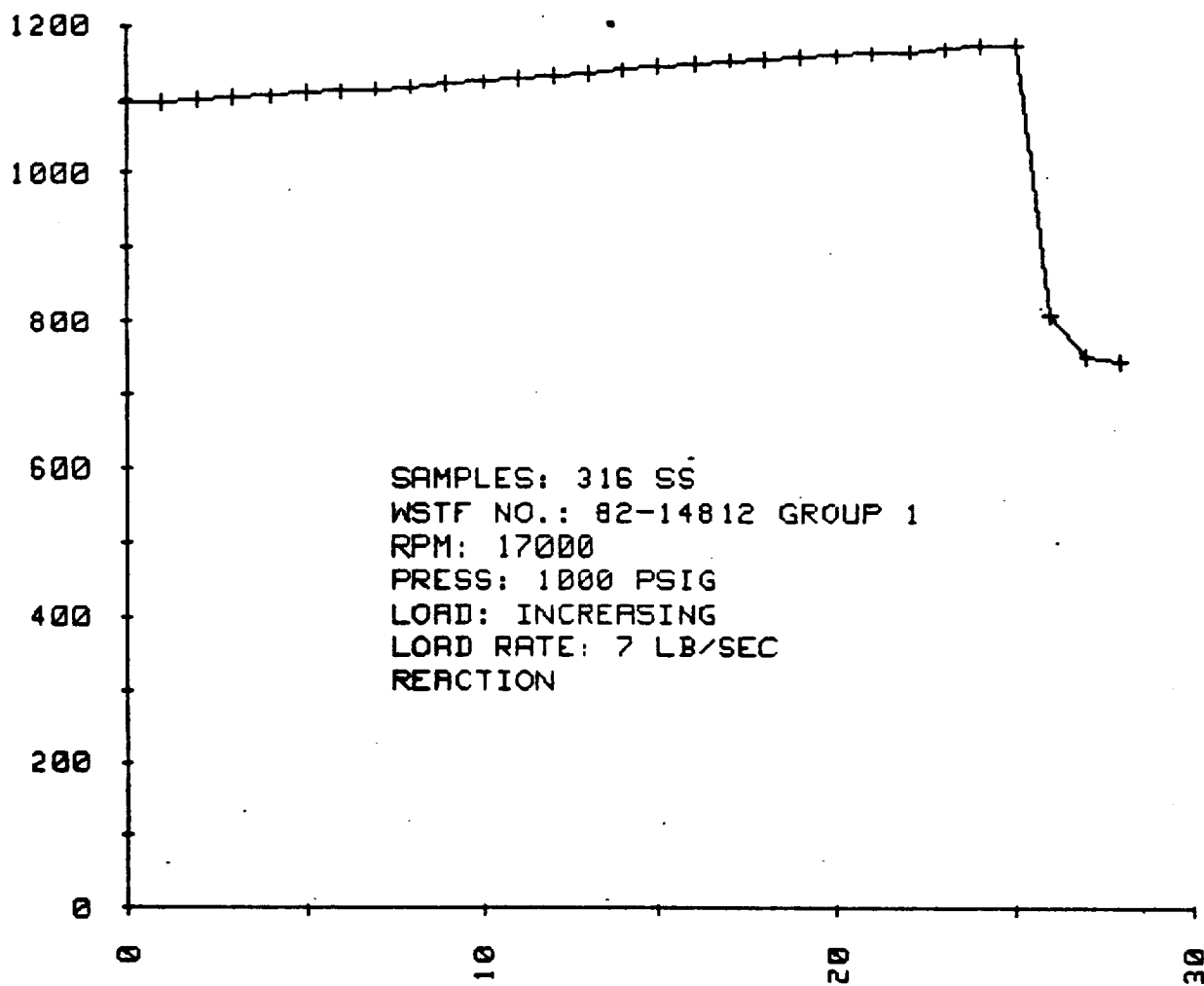
TIME (SECONDS)

FRT #143 TEST #3 6/10/83



CHAMBER PRESSURE (PSIG)

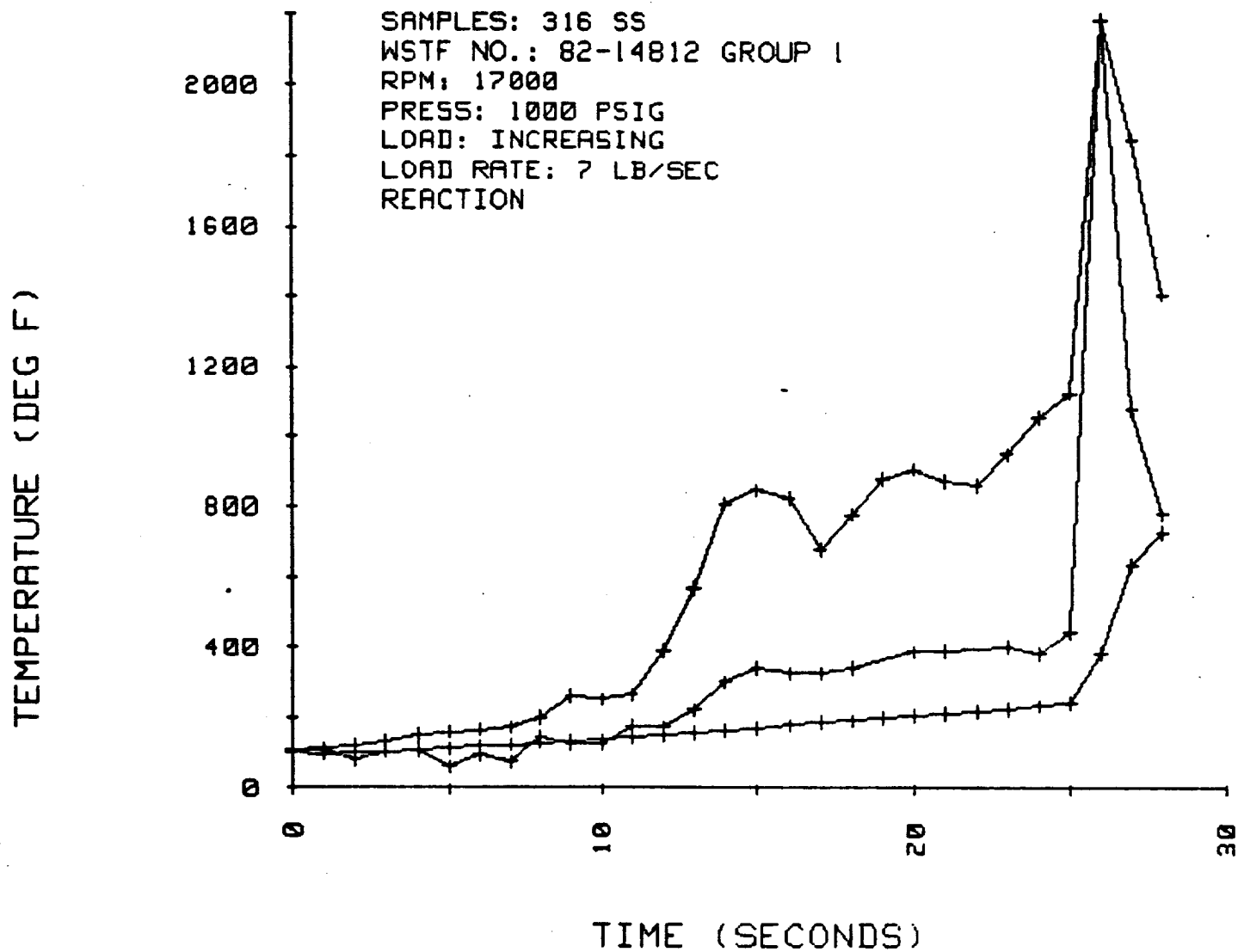
FRT #143 TEST #3 6/10/83



SAMPLES: 316 SS
WSTF NO.: 82-14812 GROUP 1
RPM: 17000
PRESS: 1000 PSIG
LOAD: INCREASING
LOAD RATE: 7 LB/SEC
REACTION

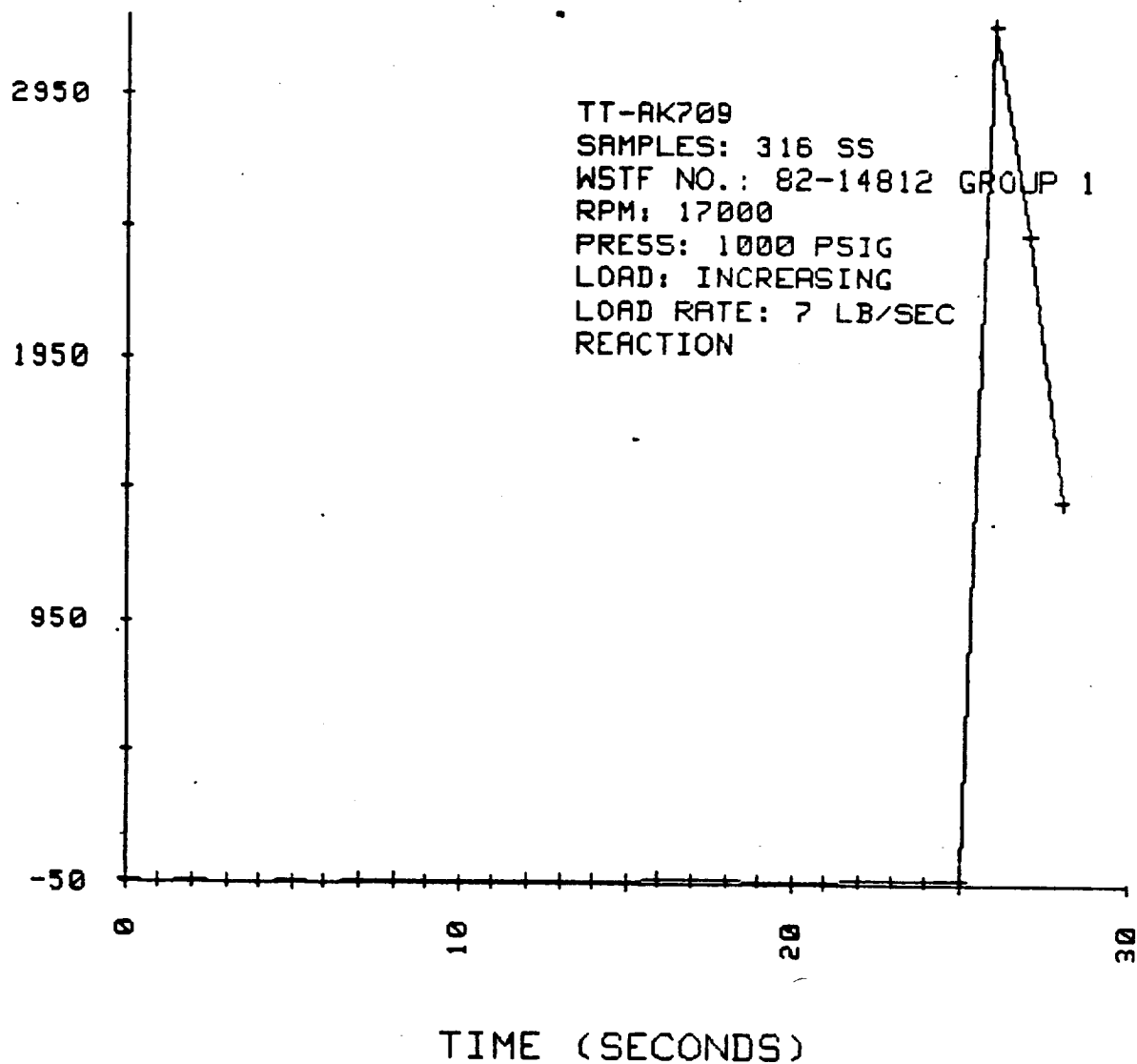
TIME (SECONDS)

FRT #143 TEST #3 6/10/83



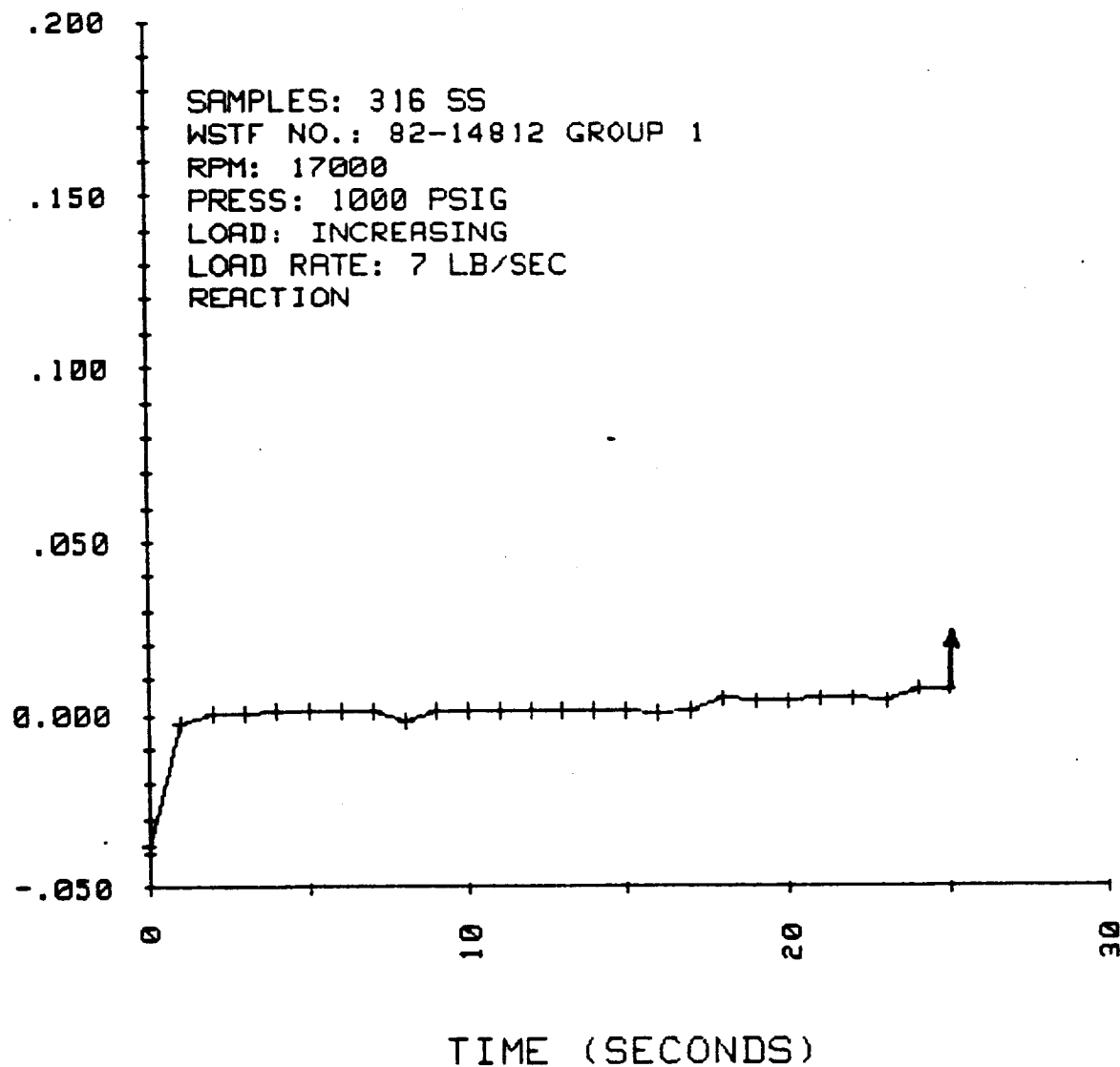
THERMOPILE OUTPUT (1/100MV)

FRT #143 TEST #3 6/10/83



SAMPLE DISPLACEMENT (INCHES)

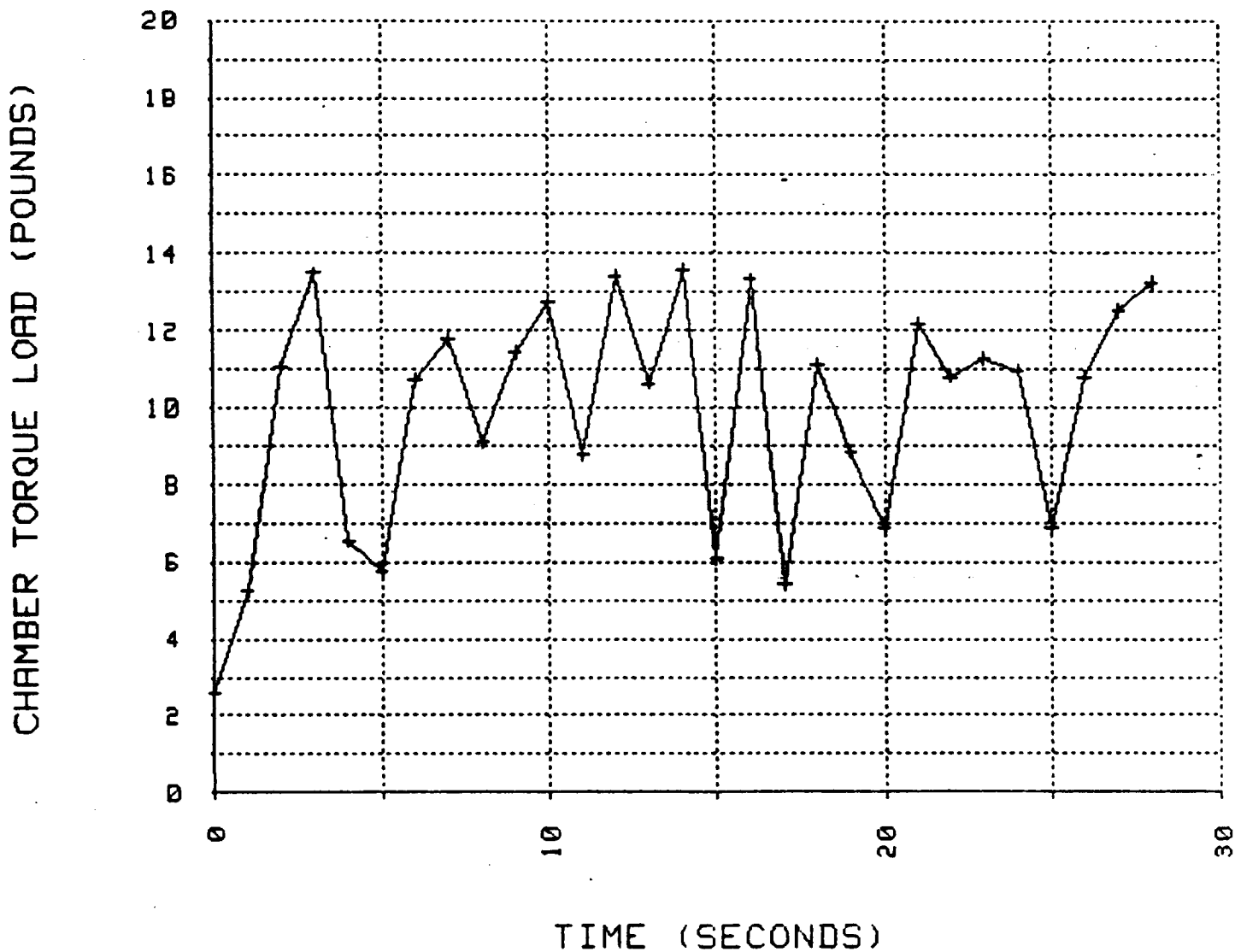
FRT #143 TEST #3 6/10/83



FRT #143

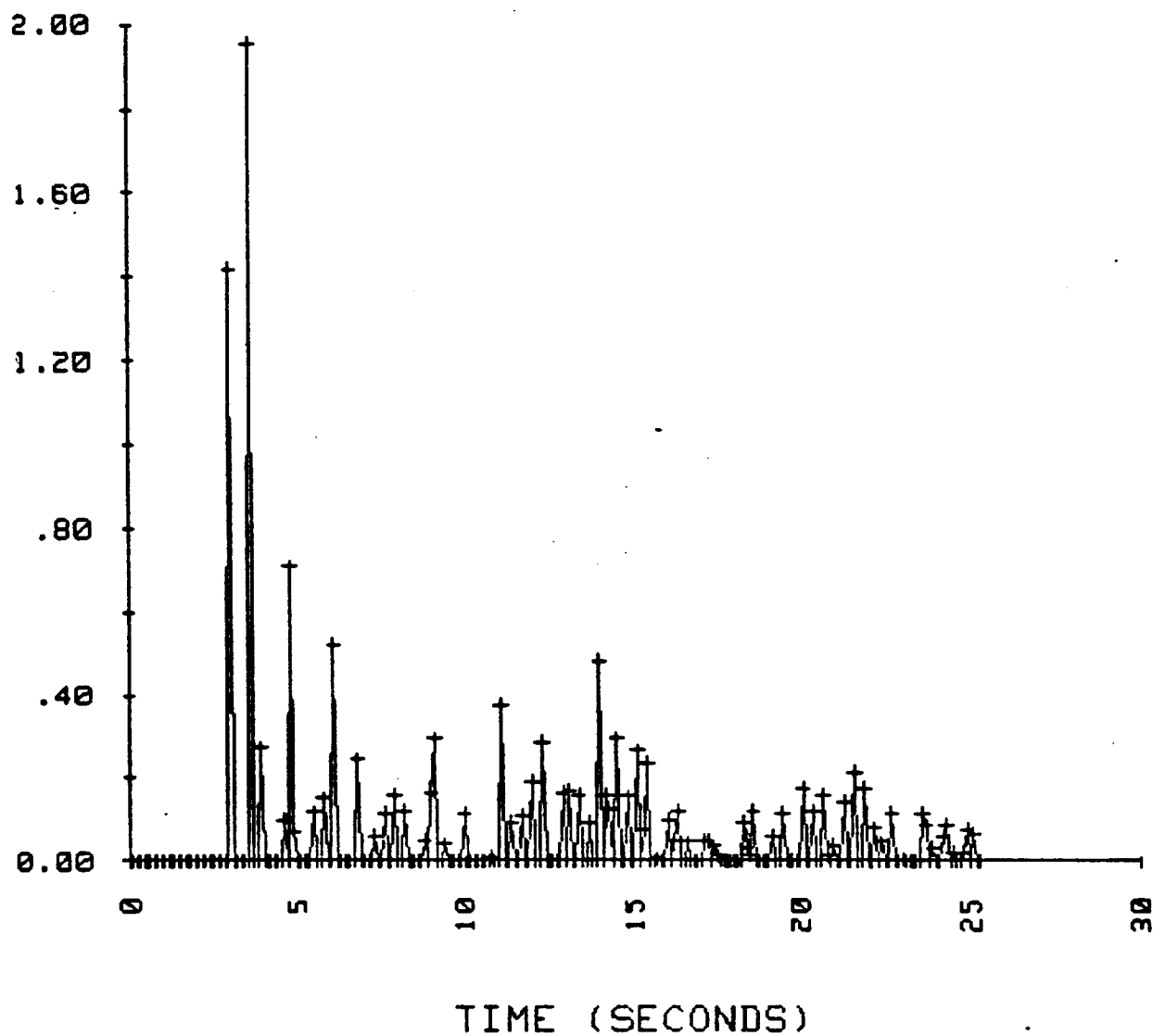
SAMPLES: 316 SS
TEST RESULTS: REACTION

SPEED: 17000 RPM (67 FT/SEC)
PRESS: 1000 PSIG
TYPE OF LOAD: INCREASING
LOAD RATE: 7 LB/SEC (25 PSI/SEC)



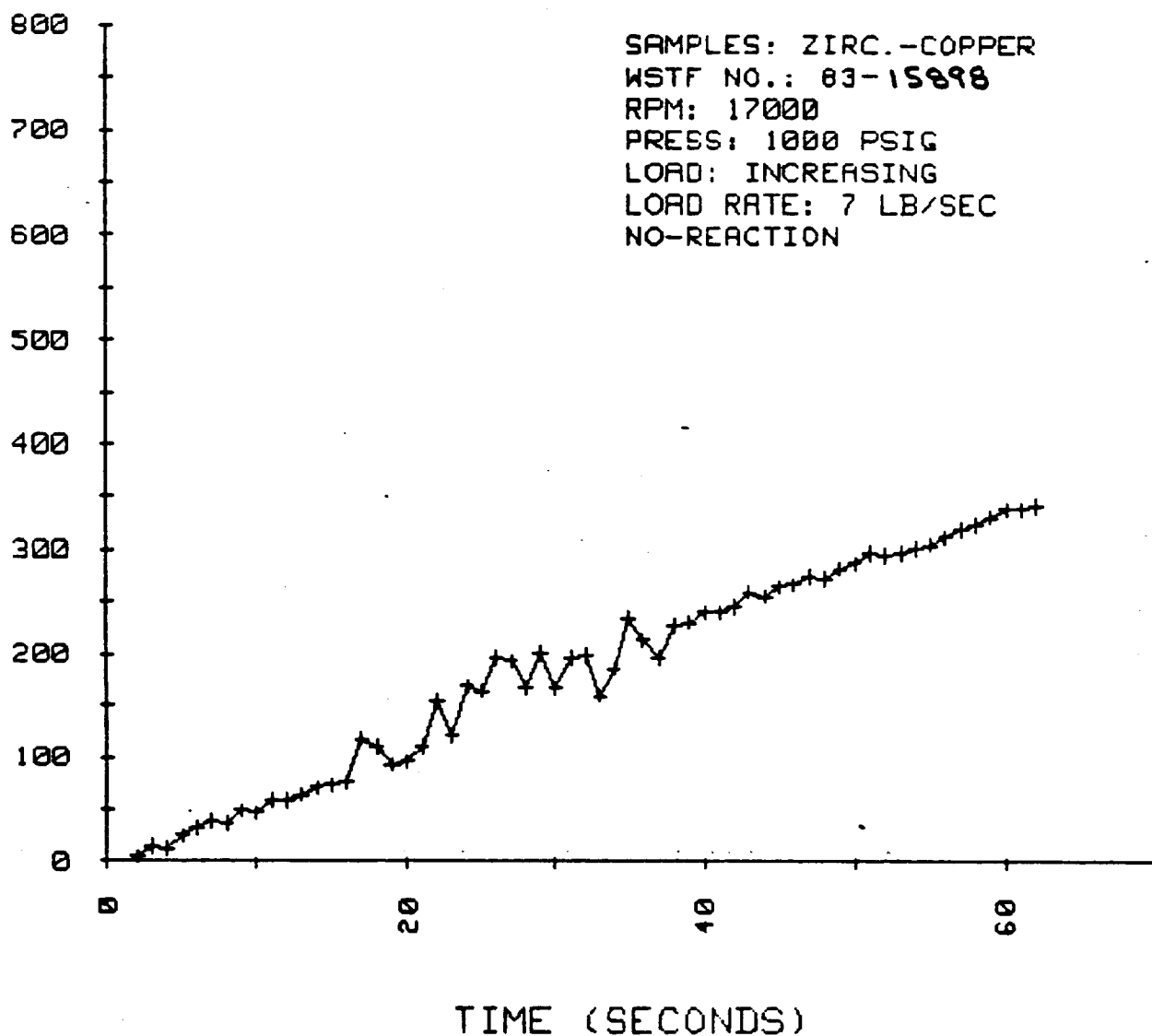
COEFFICIENT OF FRICTION

FRT #143 6/14/83

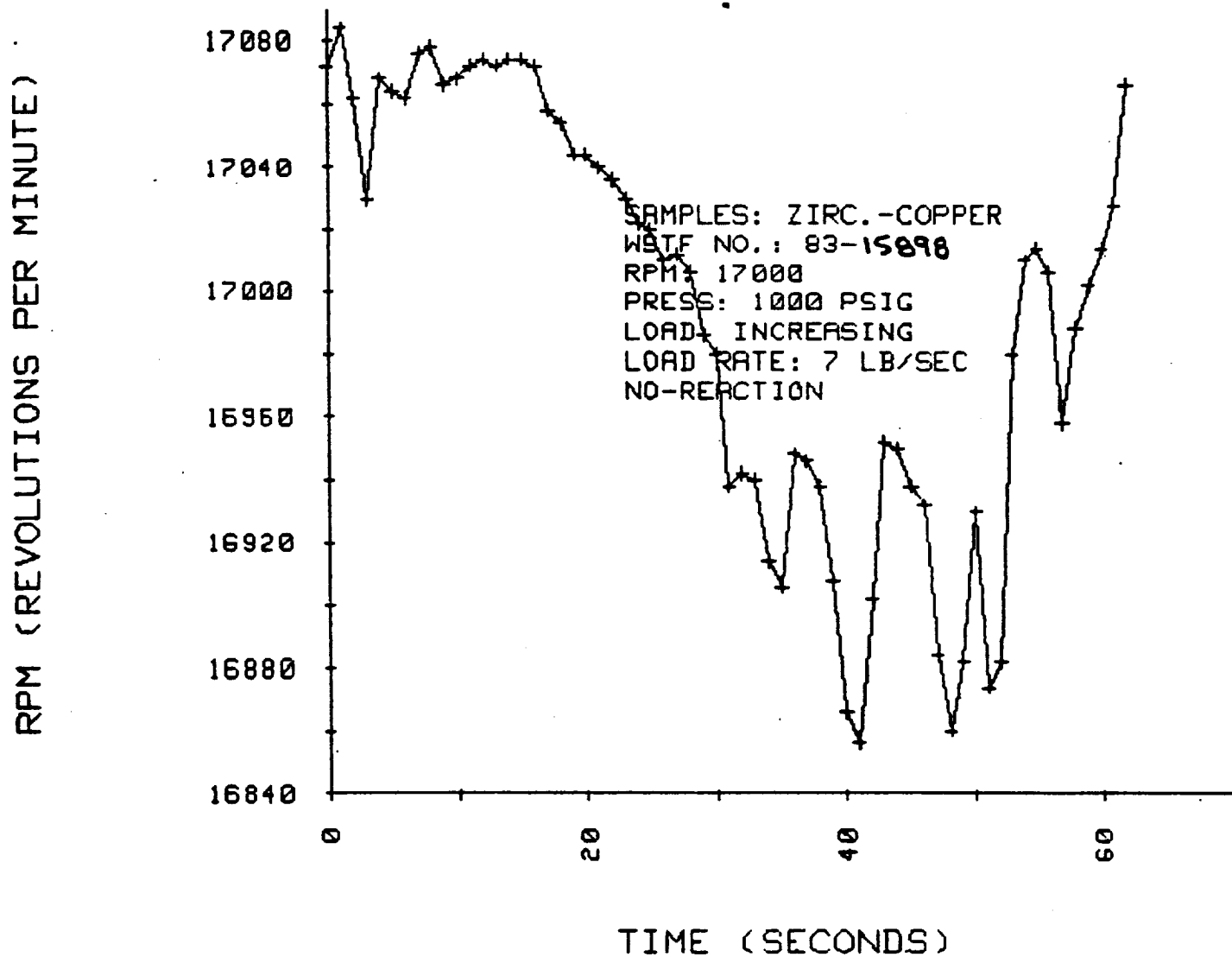


FRT #146 TEST #1 6/15/83

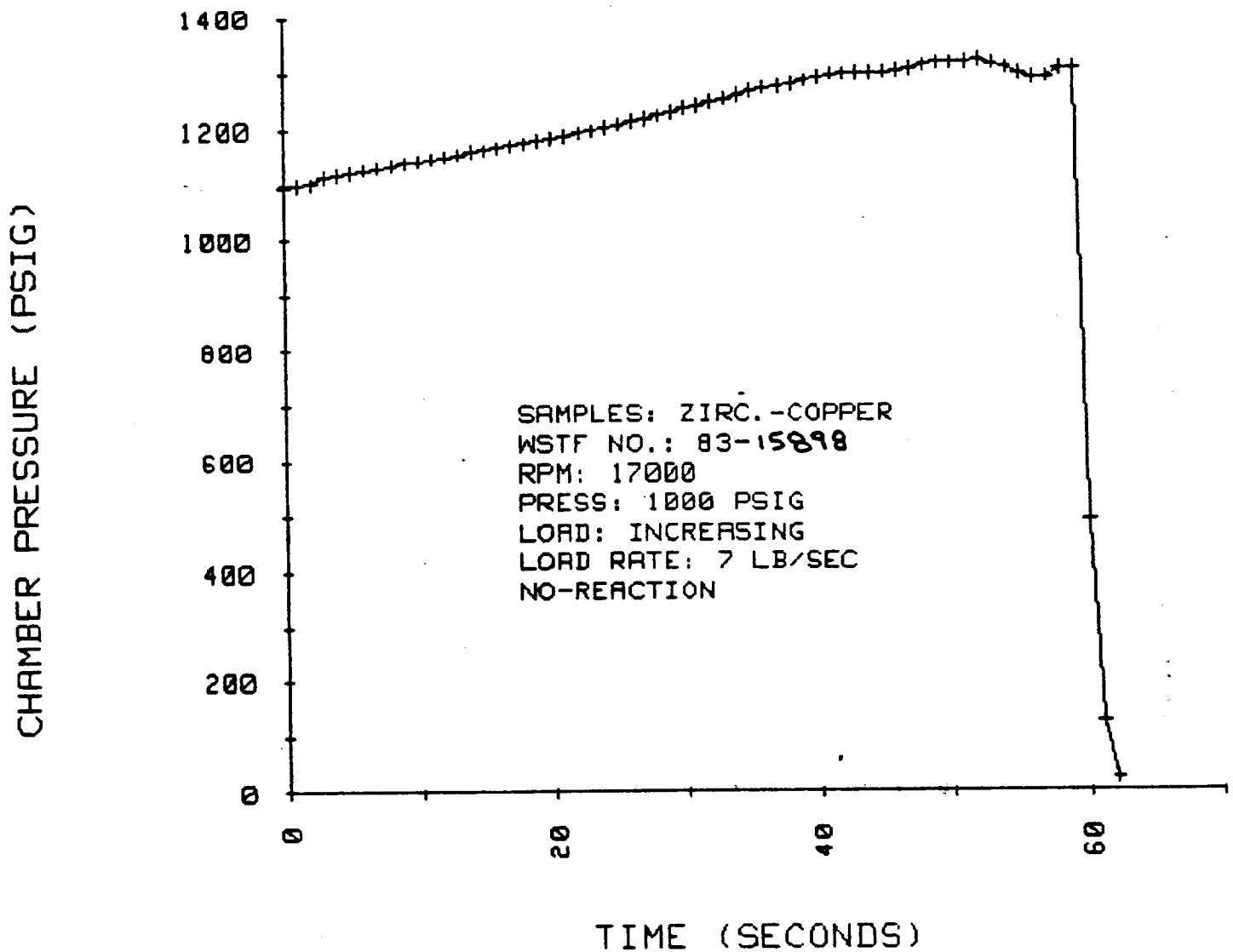
SAMPLE LOAD (POUNDS)



FRT #146 TEST #1 6/15/83

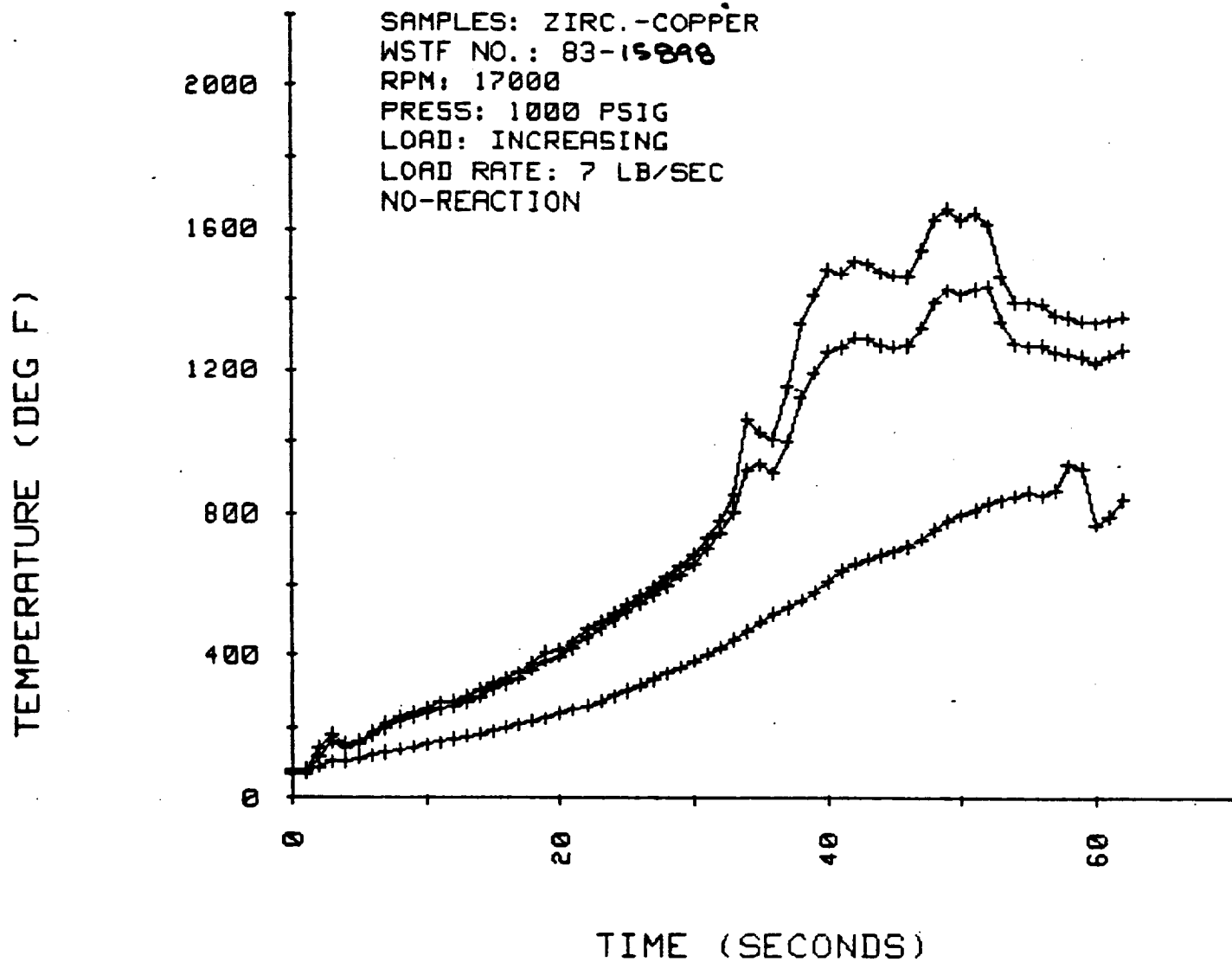


FRT #146 TEST #1 6/15/83



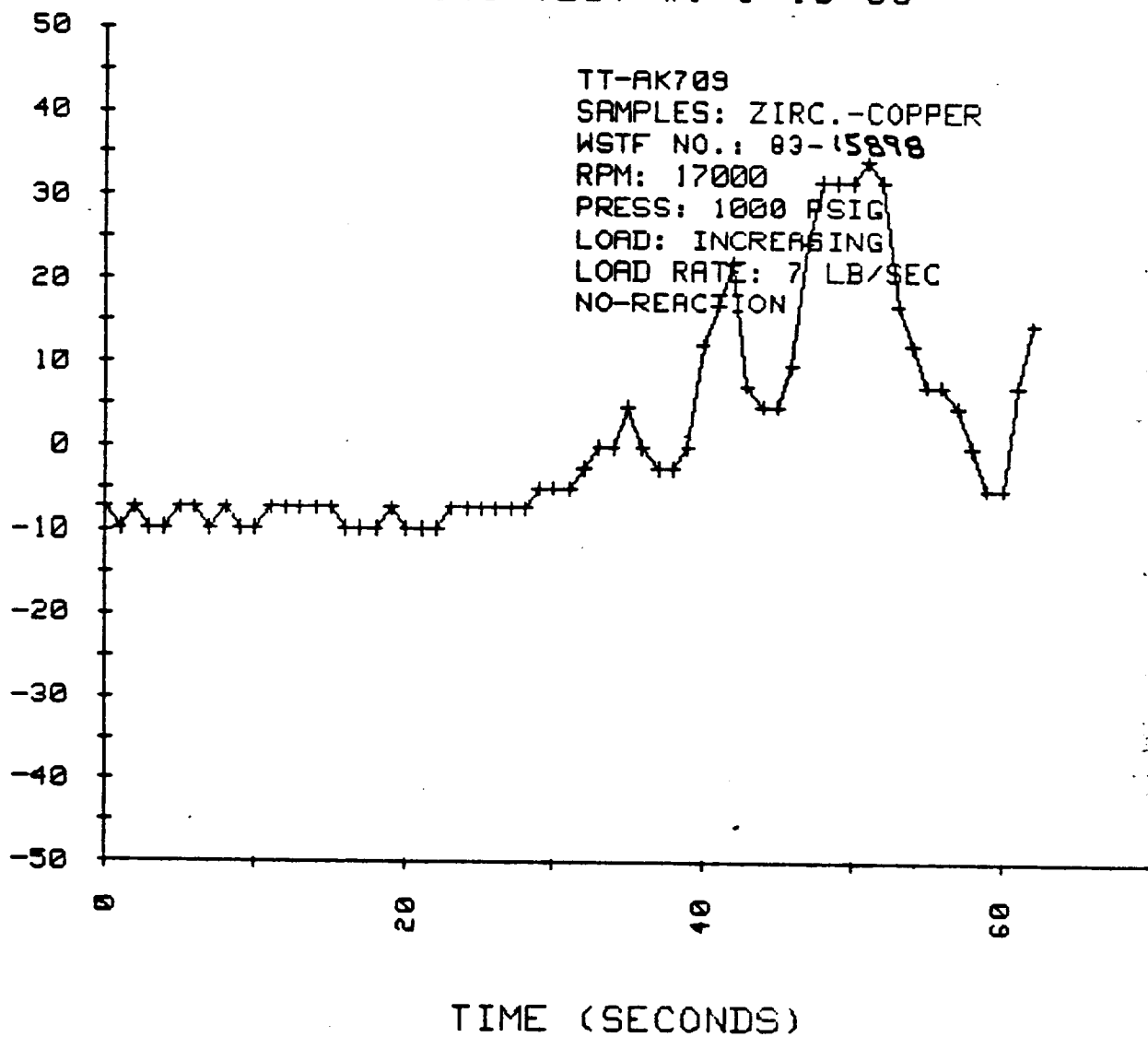
FRT #146 TEST #1 6/15/83

SAMPLES: ZIRC.-COPPER
WSTF NO.: 83-152A8
RPM: 17000
PRESS: 1000 PSIG
LOAD: INCREASING
LOAD RATE: 7 LB/SEC
NO-REACTION



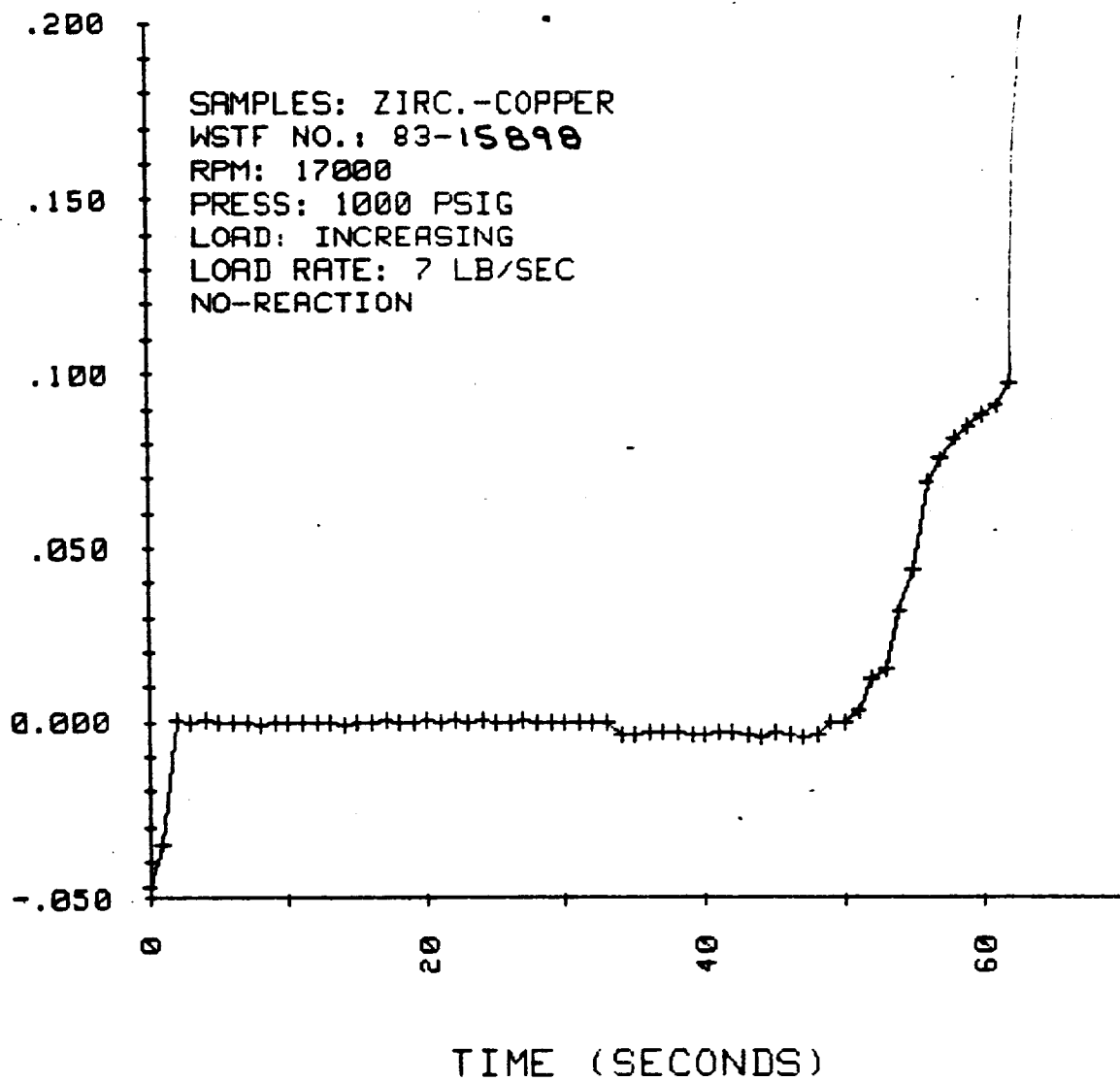
FRT #146 TEST #1 6/15/83

THERMOPILE OUTPUT (1/100MV)



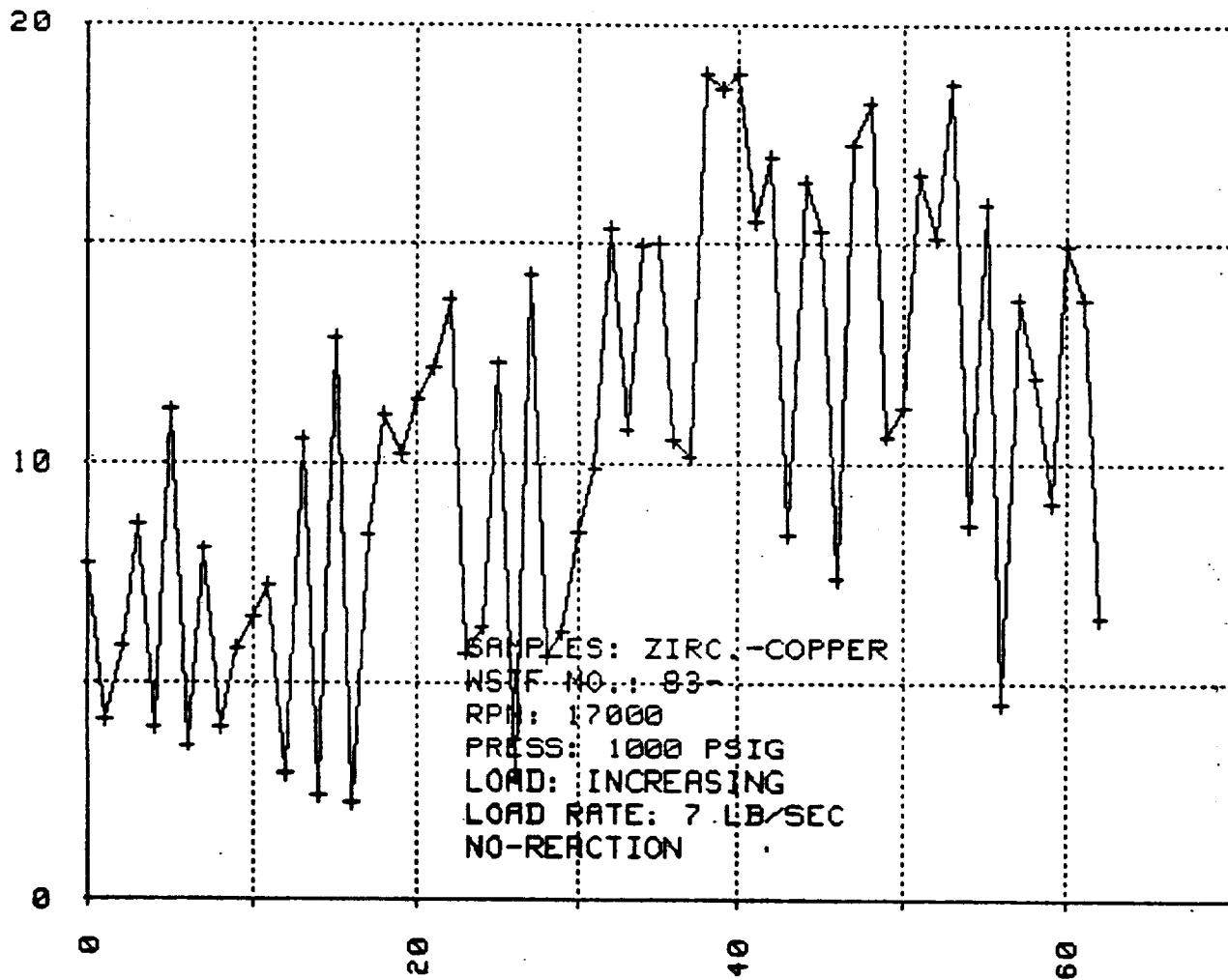
SAMPLE DISPLACEMENT (INCHES)

FRT #146 TEST #1 6/15/83



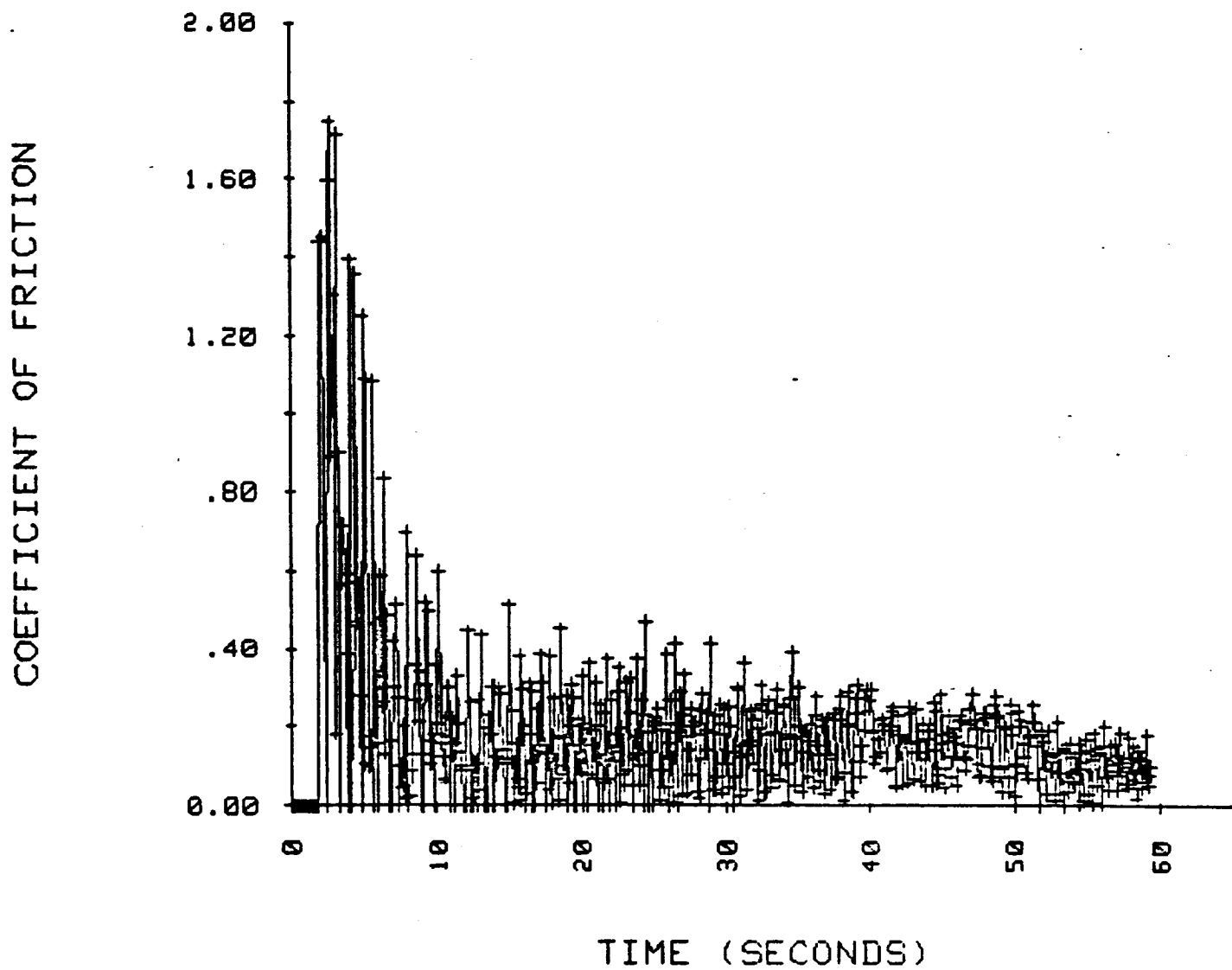
FRT #146 TEST #1 6/15/83

CHAMBER TORQUE LOAD (POUNDS)



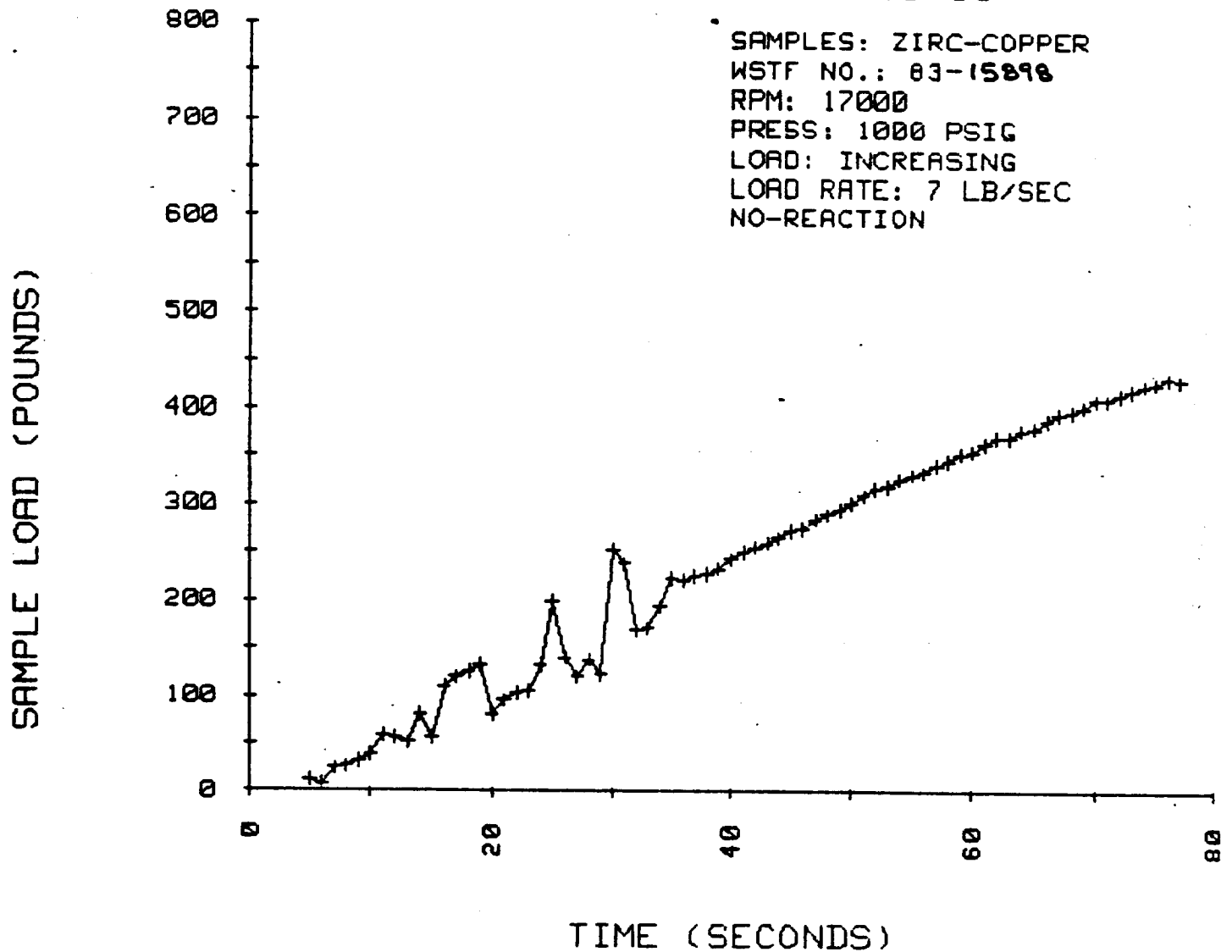
TIME (SECONDS)

FRT #146 6/15/83



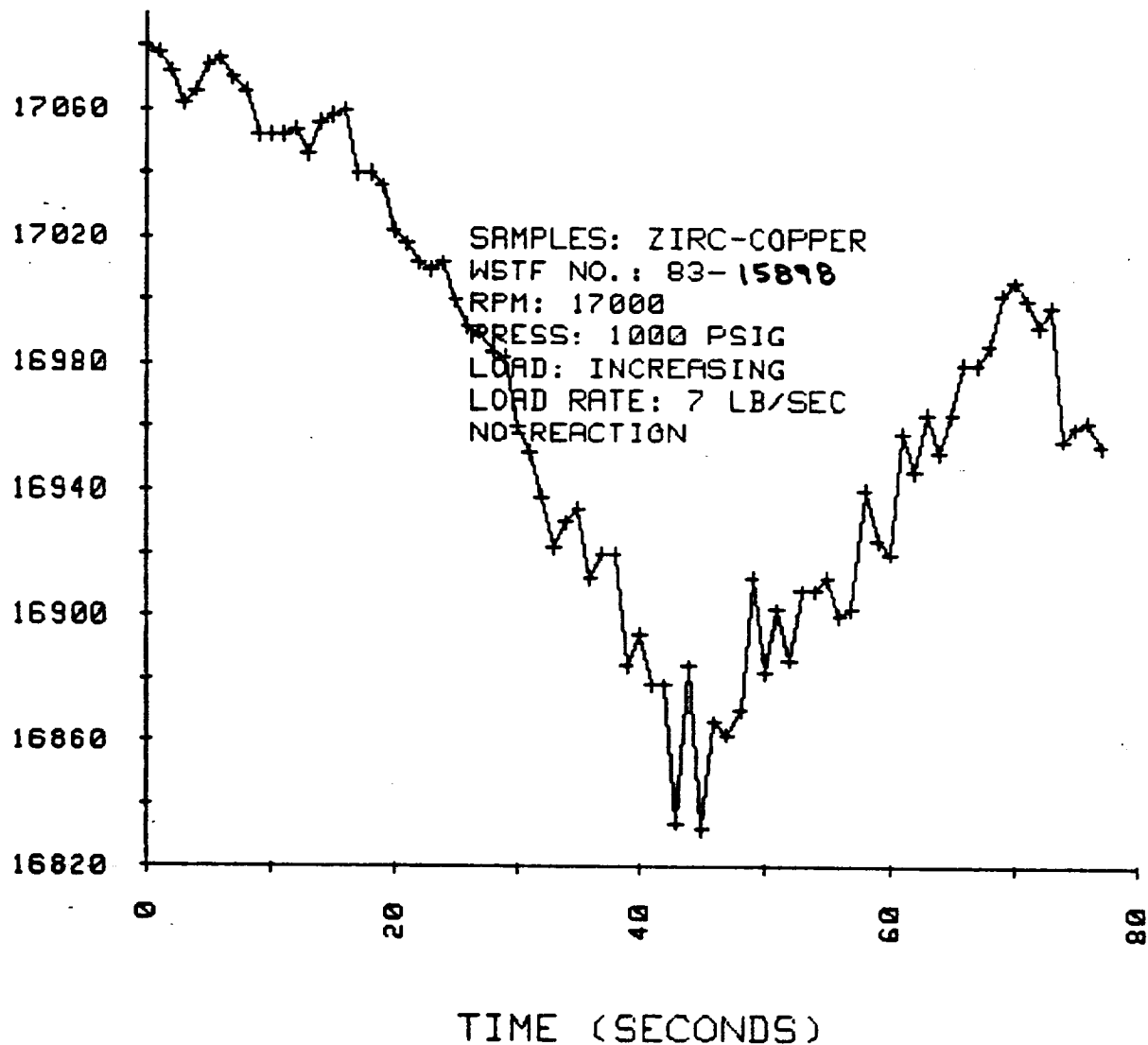
FRT #147 TEST #2 6/15/83

SAMPLES: ZIRC-COPPER
WSTF NO.: 83-15898
RPM: 17000
PRESS: 1000 PSIG
LOAD: INCREASING
LOAD RATE: 7 LB/SEC
NO-REACTION



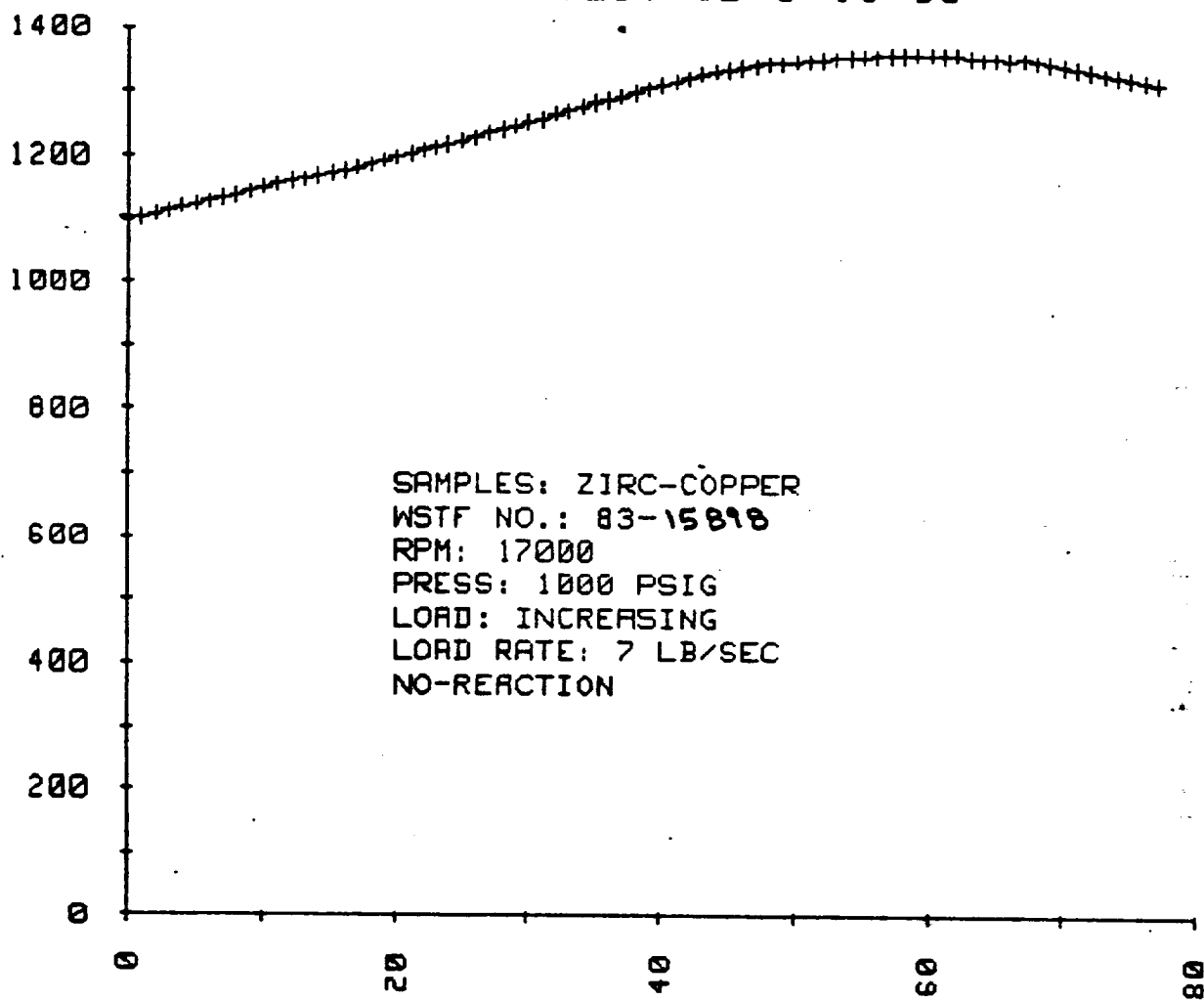
FRT #147 TEST #2 6/15/83

RPM (REVOLUTIONS PER MINUTE)



CHAMBER PRESSURE (PSIG)

FRT #147 TEST #2 6/15/83



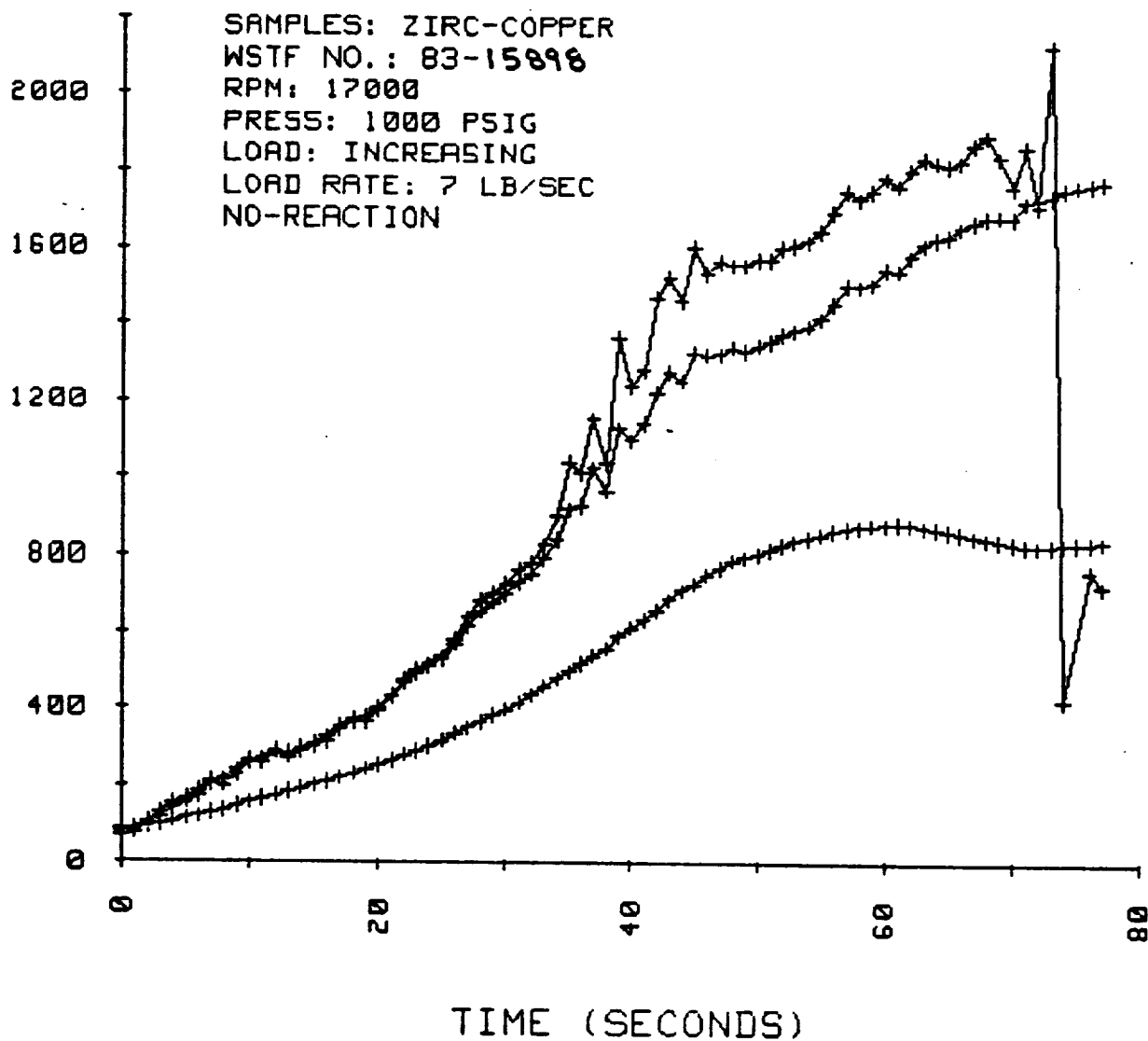
SAMPLES: ZIRC-COPPER
WSTF NO.: 83-15818
RPM: 17000
PRESS: 1000 PSIG
LOAD: INCREASING
LOAD RATE: 7 LB/SEC
NO-REACTION

TIME (SECONDS)

FRT #147 TEST #2 6/15/83

SAMPLES: ZIRC-COPPER
WSTF NO.: 83-15898
RPM: 17000
PRESS: 1000 PSIG
LOAD: INCREASING
LOAD RATE: 7 LB/SEC
NO-REACTION

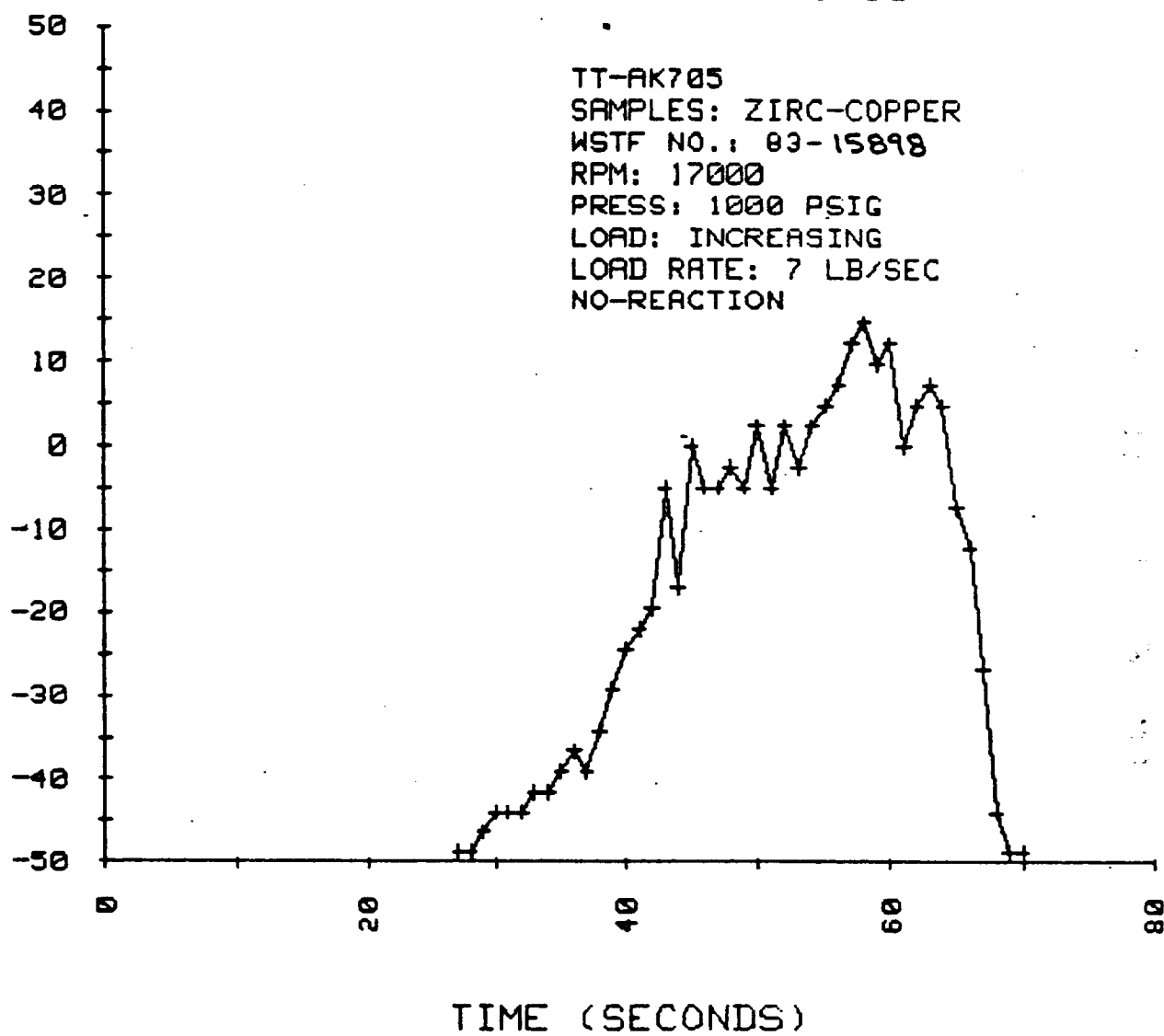
TEMPERATURE (DEG F)



FRT #147 TEST #2 6/15/83

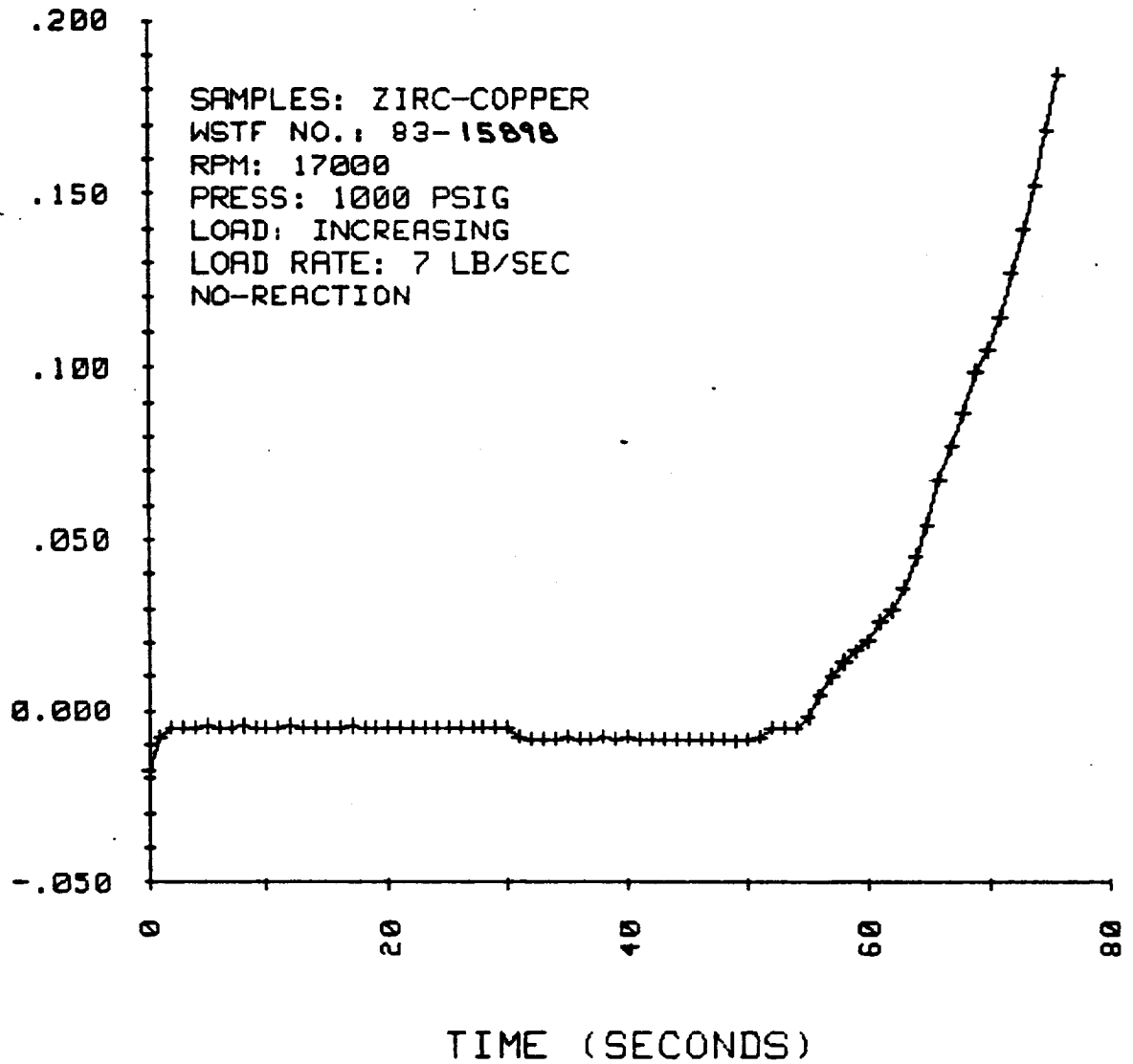
TT-AK705
SAMPLES: ZIRC-COPPER
WSTF NO.: 83-15898
RPM: 17000
PRESS: 1000 PSIG
LOAD: INCREASING
LOAD RATE: 7 LB/SEC
NO-REACTION

THERMOPILE OUTPUT (1/100MV)



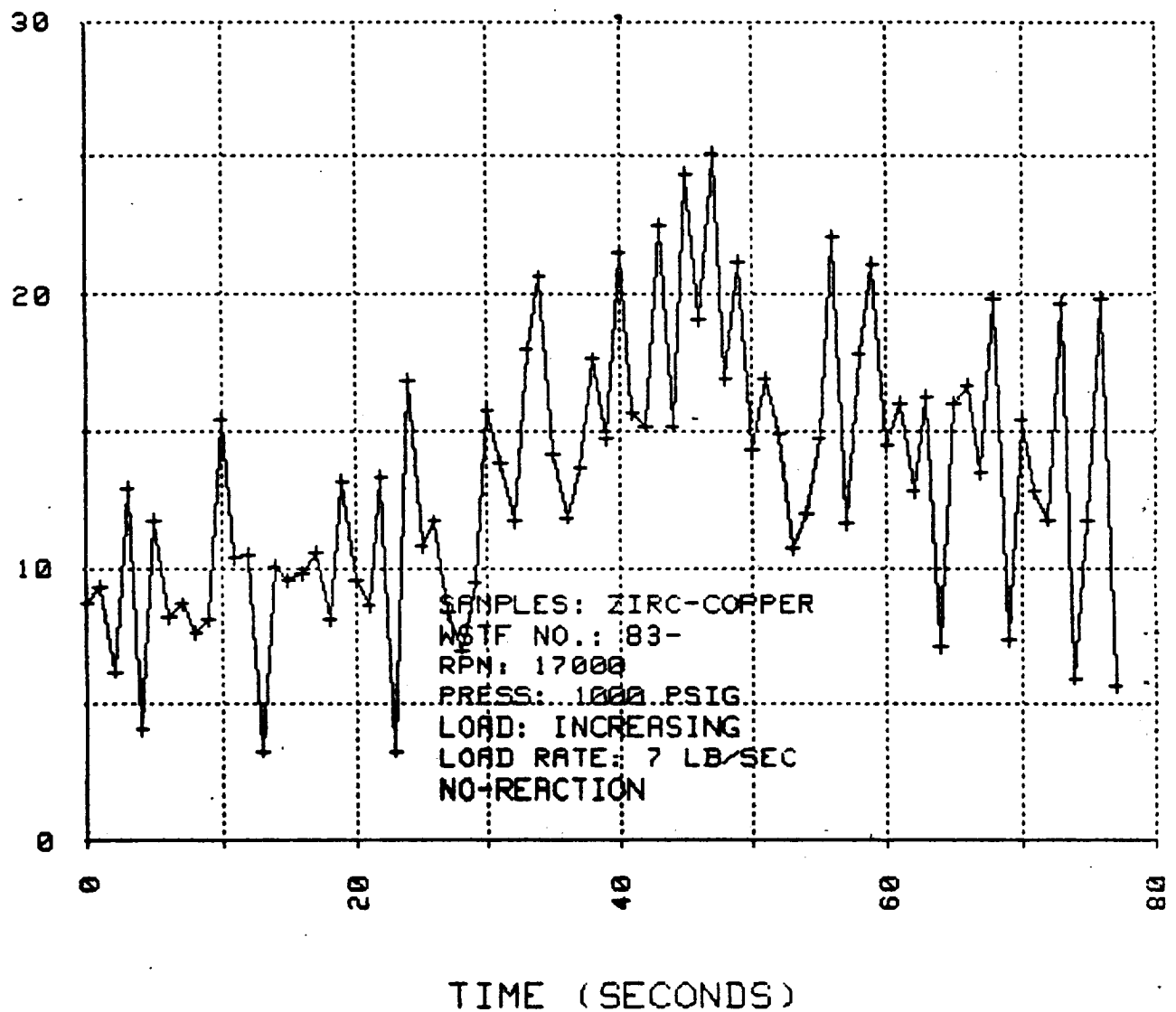
FRT #147 TEST #2 6/15/83

SAMPLE DISPLACEMENT (INCHES)



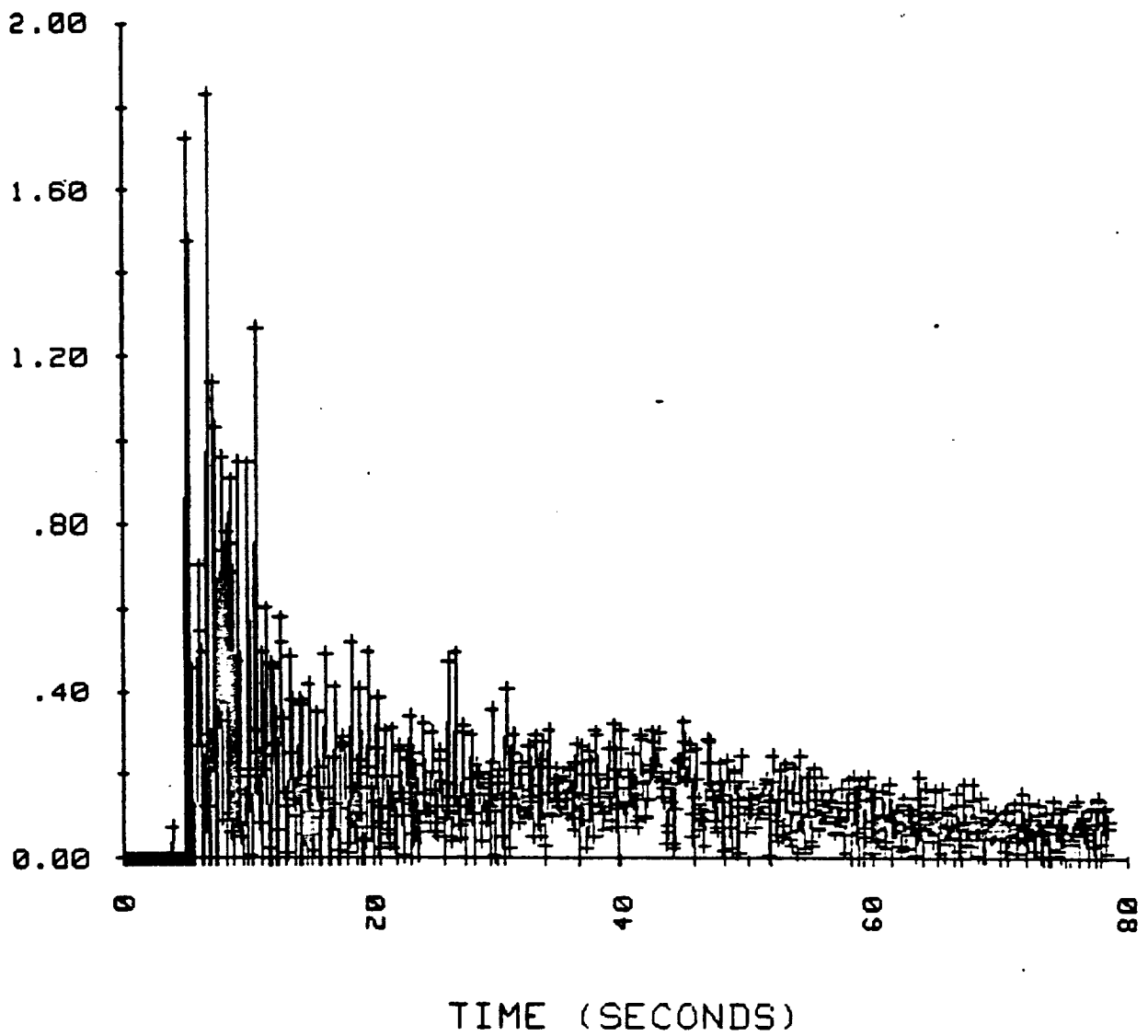
FRT #147 TEST #2 6/15/83

CHAMBER TORQUE LOAD (POUNDS)



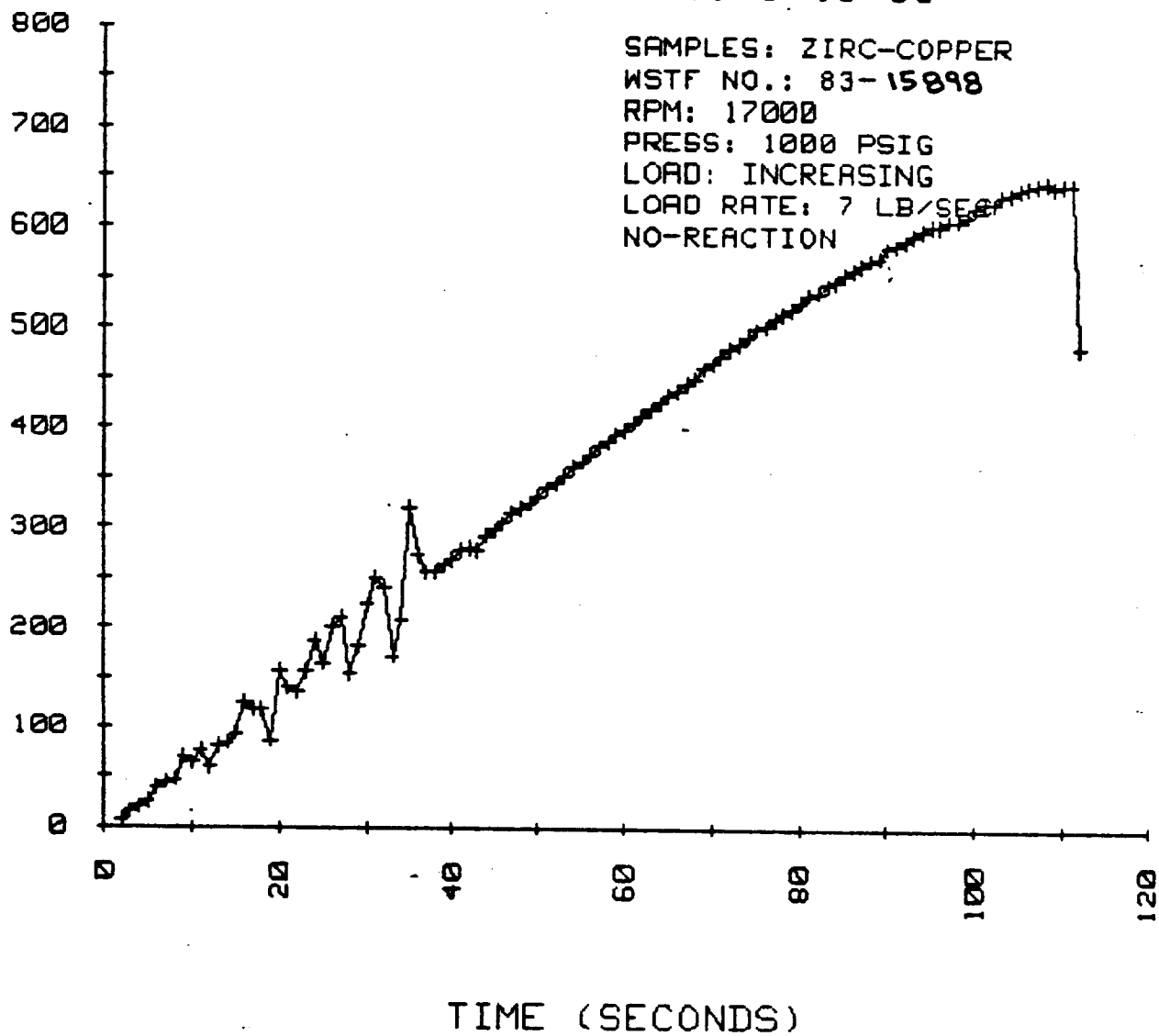
FRT #147 6/15/83

COEFFICIENT OF FRICTION



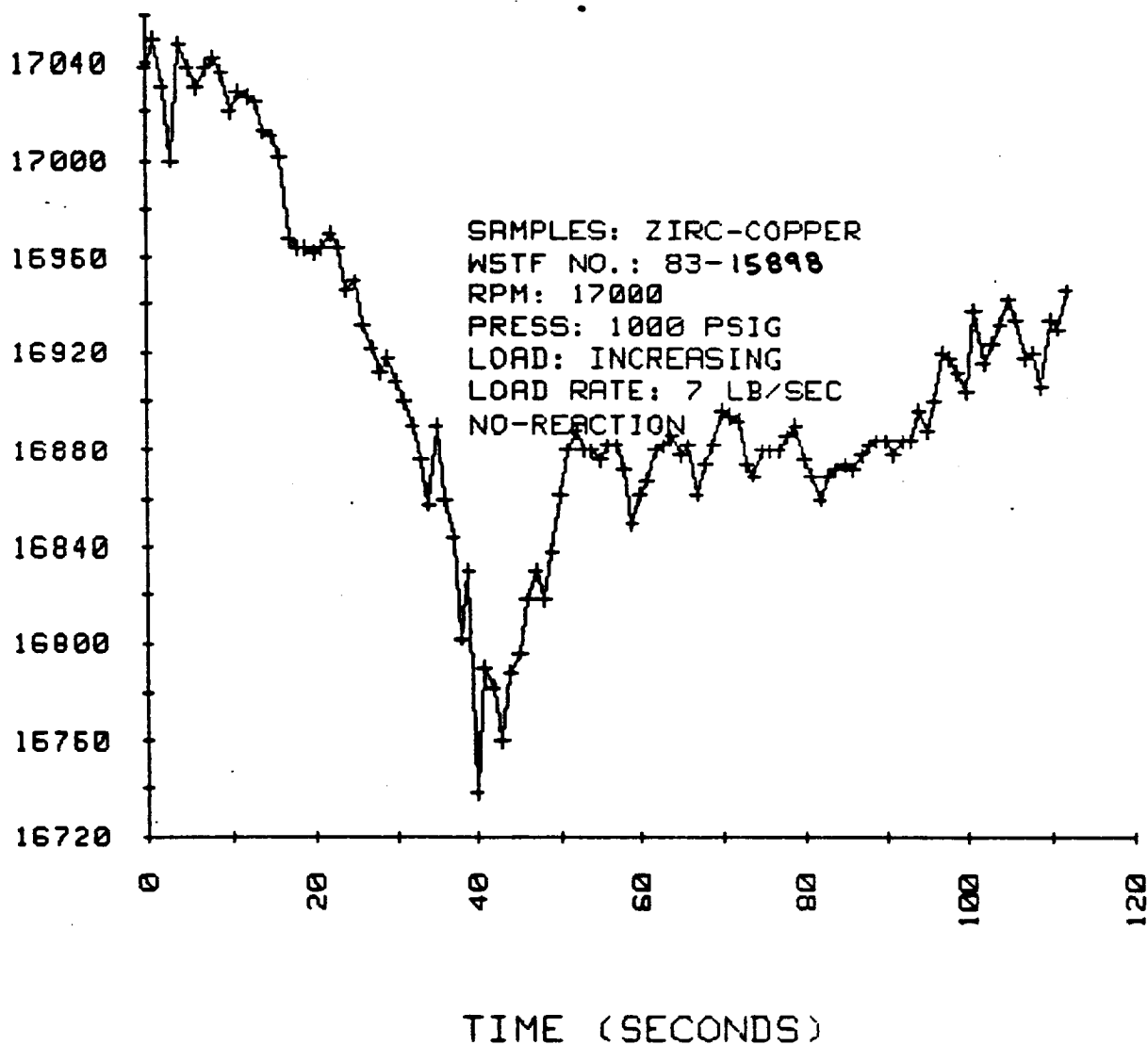
FRT #148 TEST #1 6/16/83

SAMPLE LOAD (POUNDS)



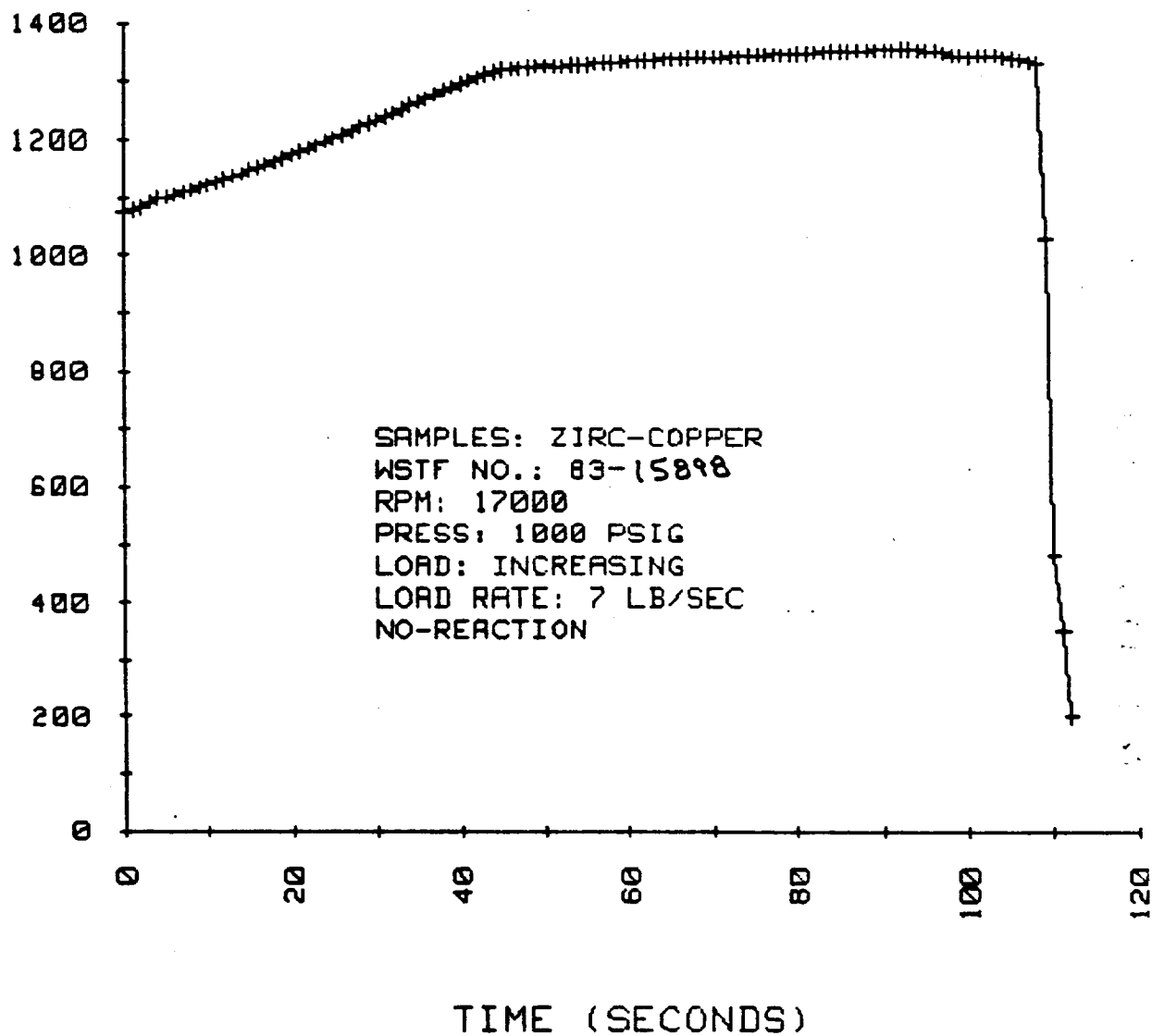
FRT #148 TEST #1 6/16/83

RPM (REVOLUTIONS PER MINUTE)



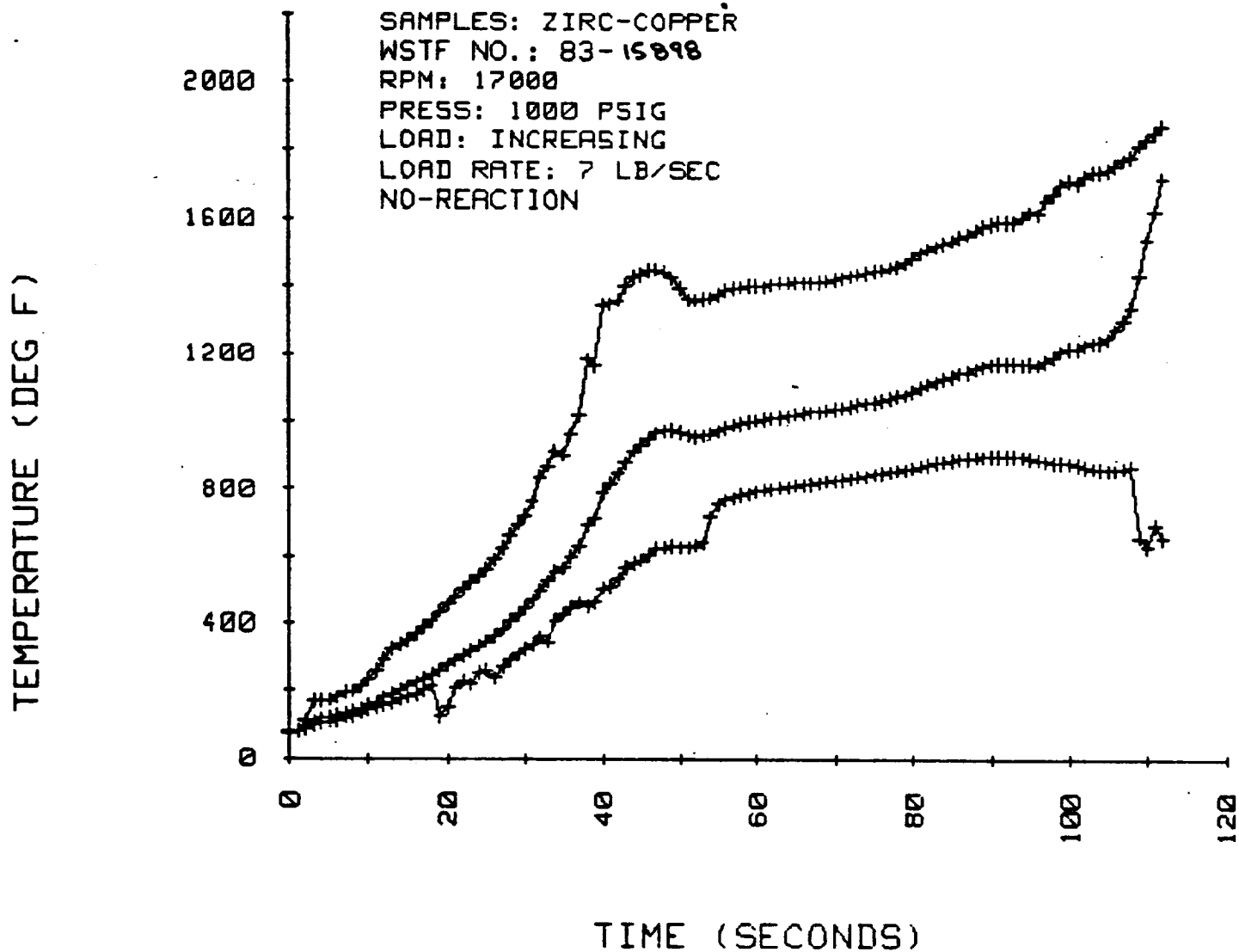
CHAMBER PRESSURE (PSIG)

FRT #148 TEST #1 6/16/83



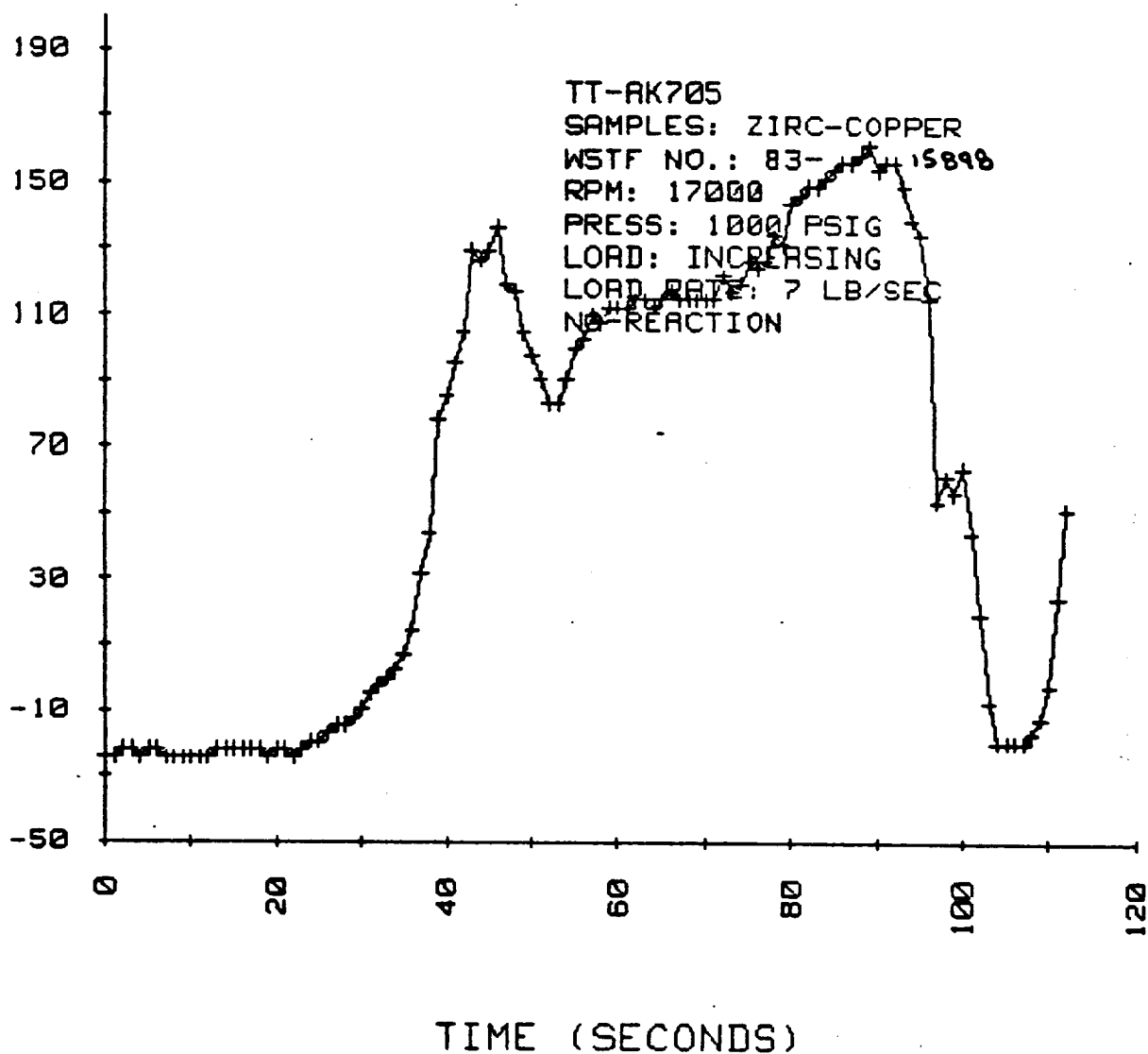
FRT #148 TEST #1 6/16/83

SAMPLES: ZIRC-COPPER
WSTF NO.: 83-15898
RPM: 17000
PRESS: 1000 PSIG
LOAD: INCREASING
LOAD RATE: 7 LB/SEC
NO-REACTION



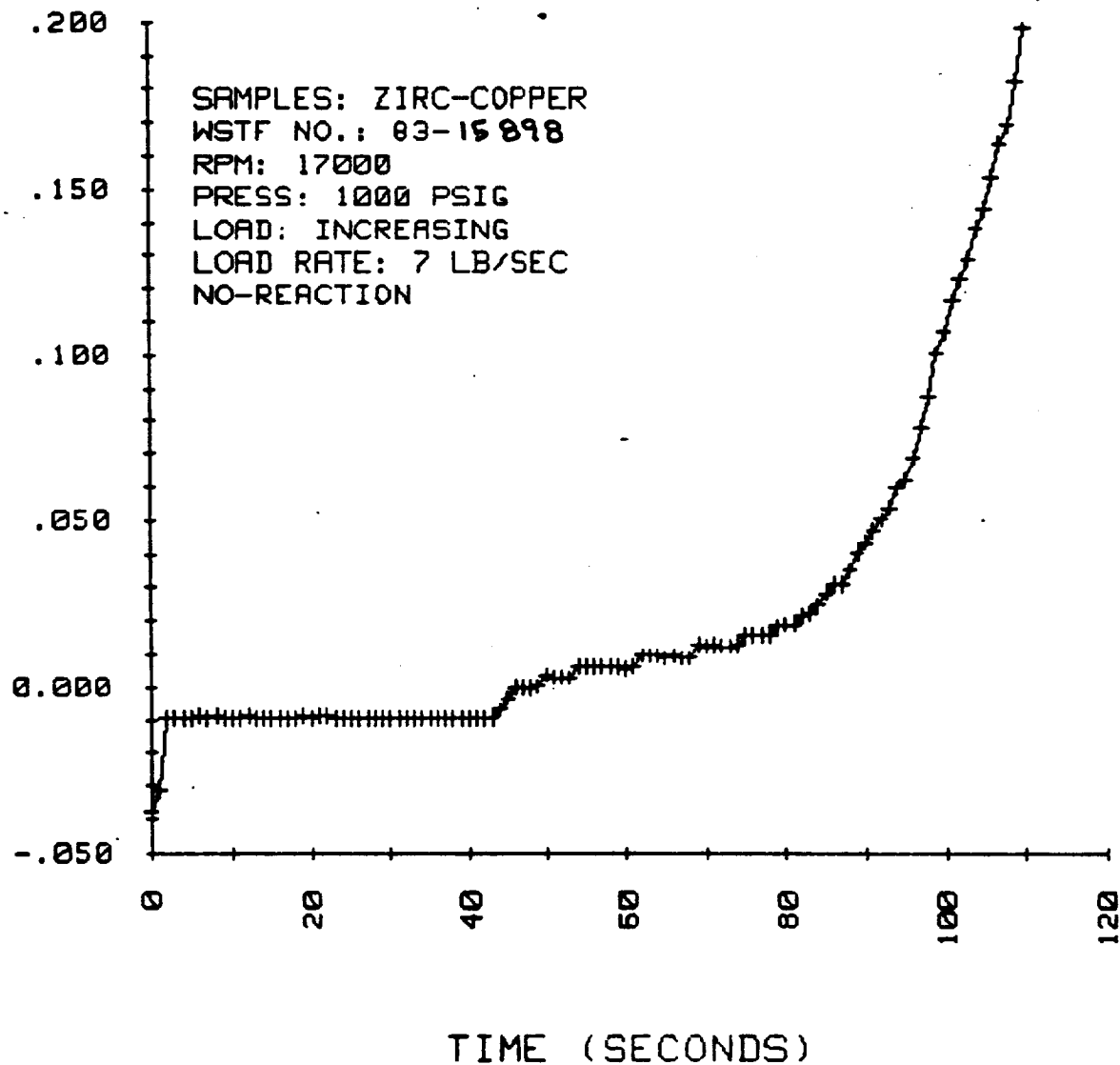
FRT #148 TEST #1 6/16/83

THERMOPILE OUTPUT (1/100MV)



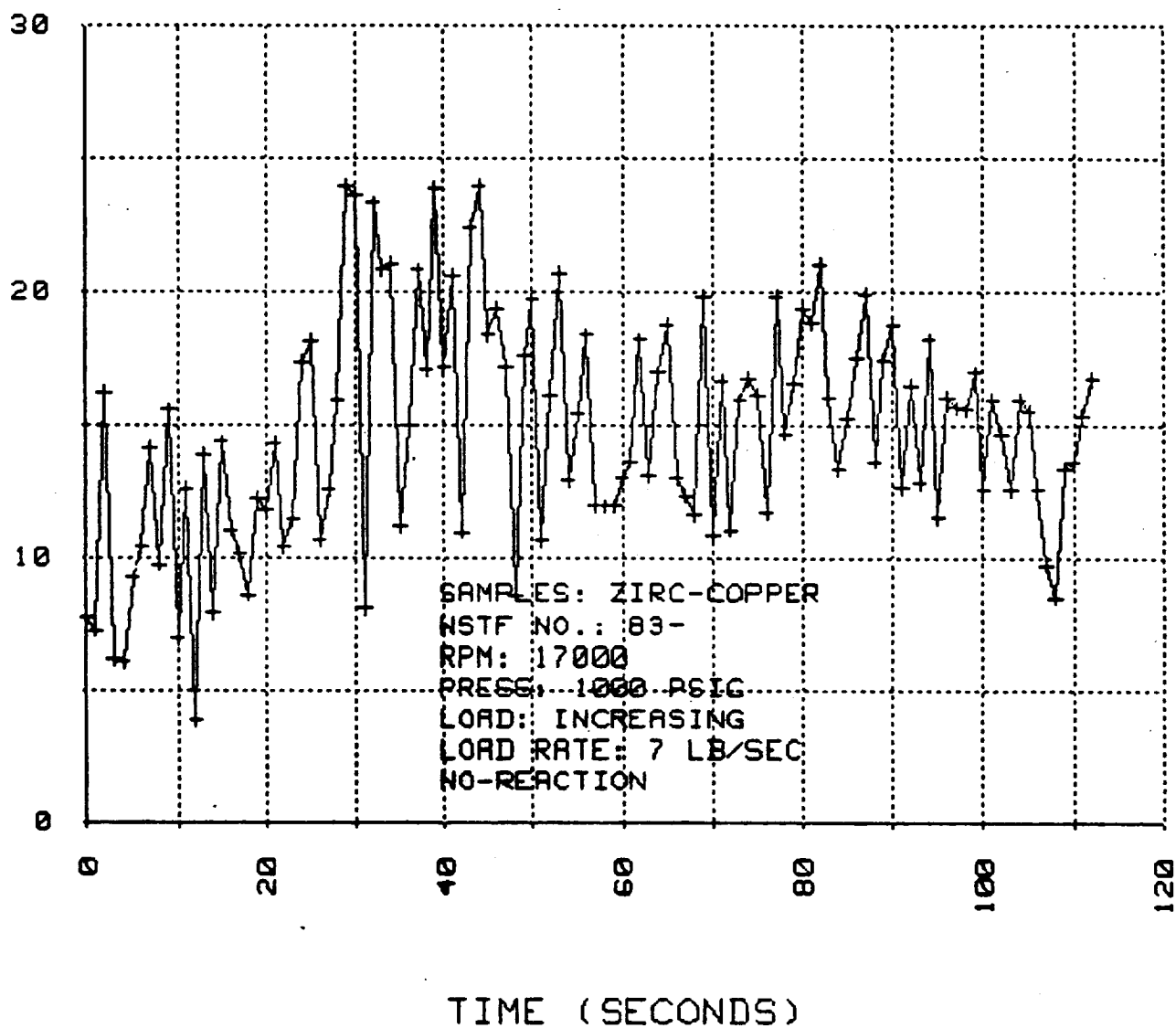
SAMPLE DISPLACEMENT (INCHES)

FRT #148 TEST #1 6/16/83



FRT #148 TEST #1 6/16/83

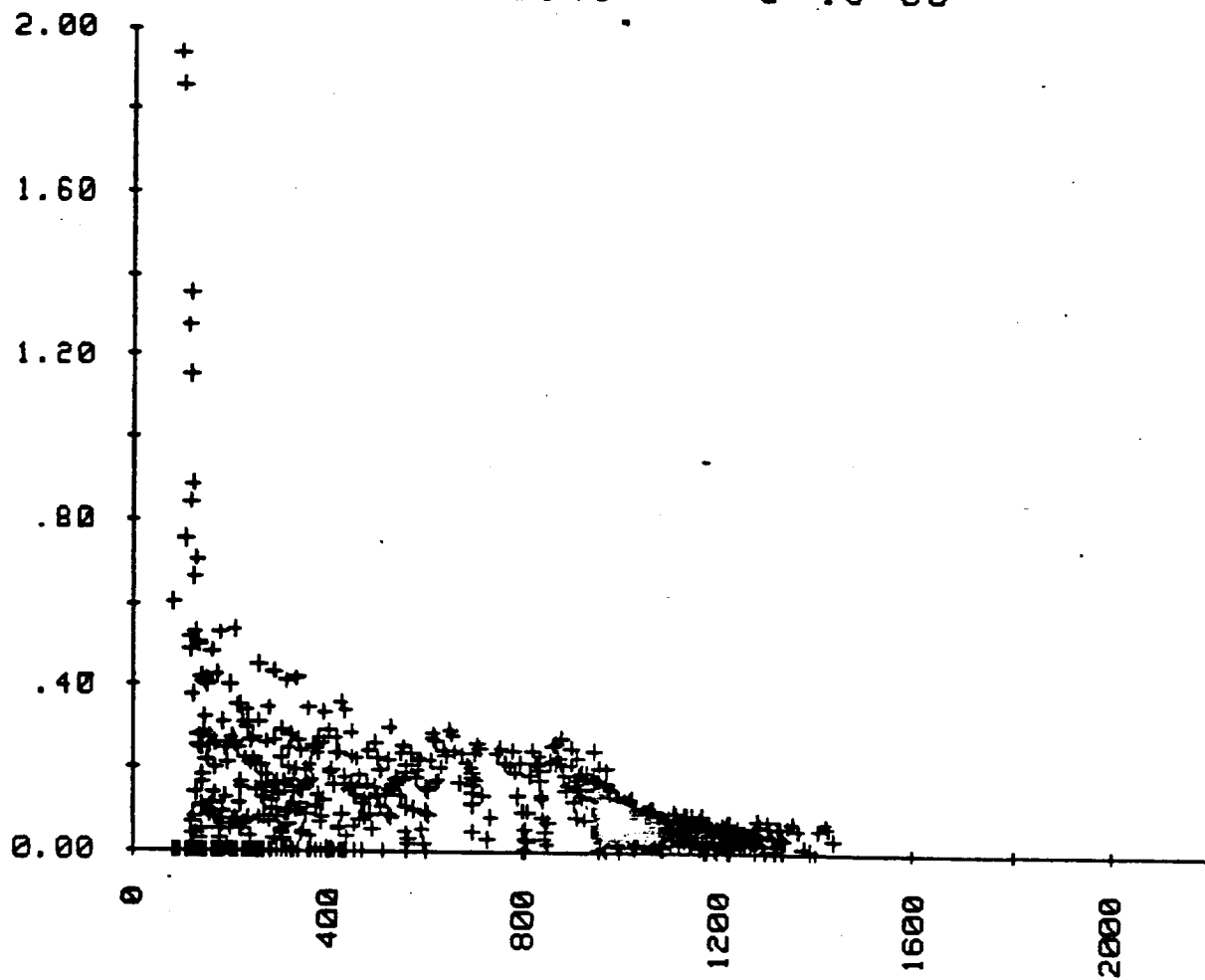
CHAMBER TORQUE LOSS (POUNDS)



COEFFICIENT OF FRICTION

FRT #148

6/16/83



TEMPERATURE - .05 IN (DEG F)